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THE ROENTGEN DIAGNOSIS OF DISEASES OF THE ALIMENTARY CANAL

BY

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PREFACE TO SECOND EDITION

In the second edition of this book advantage has been taken of the opportunity of bringing all chapters, many of which have undergone revision, up to date.

This edition has been enlarged by 98 pages, 122 illustrations, and many protocols.

Two new chapters appear, one (Chapter XIV) on hour-glass stomach, and another (Chapter XXX), a chronologic abstract of the published work on pneumoperitoneal diagnosis of abdominal lesions.

I wish again to thank Mrs. M. H. Mellish, Division of Publications, for general editorial supervision. I am indebted to my colleague Dr. J. H. P. Gauss for many valuable suggestions and for assistance in the reading of proof.

The Author.

Mayo Clinic.

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PREFACE

Within a very few years the roentgenologic examination of the digestive tract has become an extraordinarily efficient and practicable aid to gastro-intestinal diagnosis. The literature on the subject, though extensive, has been widely scattered through periodicals, and, at the time the preparation of this book was begun, no effort had been made in America to collect the well-established facts into a single volume.

In preparing this volume the intention has been to select and arrange in a systematic manner the records of such findings and facts as have been verified by experience and a large amount of material.

Extensive descriptions of apparatus have purposely been avoided since this subject has been rather fully dealt with in several comprehensive publications. On the other hand, detailed protocols are given of the findings in a considerable number of cases which have been under observation. For the sake of brevity, many citations of authority have been omitted, but there is no pretense that the bulk of the facts related are from original observations. Opposing views have been considered with fairness and without conscious implication that the statements herein recorded should be considered final.

Because of the lessons they may teach, mistakes have been recorded unsparingly, but these errors should not be regarded as reflecting on the efficiency of roentgen diagnosis in general.

Grateful acknowledgement is made to the distinguished brothers whose name designates the clinic in which the work has been done and who have given exceptional opportunities for the comparison of roentgenologic and operative findings, to fellow members of the surgical, clinical and pathological

staffs, who have heartily co-operated in the work, to Mrs. M. H. Mellish, Division of Publications, whose aid has been unflagging, and to the associate members in the roentgen laboratory, especially Dr. Albert Miller, who have given such generous help.

Russell D. Carman.

Mayo Clinic.

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THE ROENTGEN DIAGNOSIS OF DISEASES OF THE ALIMENTARY CANAL

CHAPTER I

APPARATUS

An adequate equipment of roentgen apparatus simplifies and facilitates the examination of the digestive tract and for such purposes can hardly be dispensed with. It is true that in this, as in many other things, the man counts for more than the machine, and the bulk of roentgenologic knowledge has been gained by those who had to content themselves with crude appliances. Yet, modern apparatus saves time and labor, invites thoroughness and lessens the chance of error.

The coil, which superseded the static machine, is still used by a few for roentgenography and to some extent for roentgenoscopy. It gives an excellent screen image, but the interrupter, whether of the vibrator, electrolytic or mercury-turbine type, is a frequent source of trouble when subjected to hard usage.

In recent years, the coil has generally yielded place to the interrupterless transformer, the development of which has been due largely to American ingenuity. Of interrupterless machines, a number of excellent makes are on the market, and the differences between them are not of great consequence. They are adaptable both to roentgenoscopy and to roentgenography and are dependable and economical in operation.

A varied assortment of vertical and horizontal screen-apparatus, tubes, tube-stands, combination-tables, automatic plate-changers for stereoscopic plates, and other minor accessory apparatus is obtainable. These accessories are constantly

undergoing modification and improvement, so that the operator can easily satisfy his personal preferences and requirements. Extensive and detailed description of apparatus would be superfluous here, since there are many recent publications which describe it adequately; however, a few remarks concerning equipment may be of practical aid.

TRANSFORMER

This piece of apparatus is used for the excitation of the roentgen tube and consists of a step-up transformer for raising the voltage and a commutating device for rectifying the high-tension or secondary current. These machines vary in capacity ranging from 2 to 15 kilowatts. It is advisable, however, to avoid extremes; machines of medium capacity are best adapted to general roentgenography.

The modern transformer for x-ray work is of the closed magnetic field type with autotransformer control and a small amount of resistance (rheostat) for fine regulation. Transformers with a parallel spark backup of 15 cm. will answer adequately for any kind of x-ray work except deep therapy where a maximum of 25 cm. is sufficient. These machines are constructed so as to operate from either the direct or alternating circuits of 220 volts. They are simple, practical, durable and efficient and obviate the need of a coil and interrupter with their annoyances. Operating control boards and protection screens are supplied with the machine.

The writer predicts that in the very near future some radical changes will be made in all forms of x-ray equipment.

VERTICAL SCREEN APPARATUS

For a number of years no one piece of apparatus has concerned roentgen work more than a suitable appliance for making screen examinations. Opinions regarding such instruments have been diversified, hinging chiefly on the question of protection, and there have been extremists pro and con. The development of such apparatus has been a matter of evolution with

regard to adequate protection, ease of manipulation, accessibility of parts, durability and avoidance of an awesome appearance. One of the most essential things in the construction of such apparatus is easy access to the patient for manipulation.

Most of these qualities are embodied in each of the various makes of vertical screen apparatus. In general, such an apparatus consists of a counterweighted tube-box which can be freely moved laterally and vertically on the frame upon which it is mounted. The box is covered with heavy sheet lead and is provided with a door at the side or back through which an interchangeable tube-holding rack can be taken in or out. A small window in the front of the box, opposite the target of the tube, is covered inside with a thin aluminum filter. This latter serves a double purpose; it filters out the soft rays and excludes the light from the tube-box. Over the outside of the window is placed an adjustable diaphragm, usually of lead reinforced with brass. The diaphragm may give either a circular (iris type) or rectangular field; the latter is the most generally used and its operation is controlled by an ingenious mechanism with a handle convenient to the operator's left hand.

In front of the tube-box is a high, wide shield, against which the patient stands during the examination. The shield may be of thick, heavy metal with an aluminum or celluloid window, or it may be made wholly of celluloid in a metal frame.

The screen is supported from the tube-box either by cords or by a crossarm with rigid suspension rods. The latter device makes it possible to move the tube and screen in unison, and keep the illuminated field in constant view.

A small turntable, on which the patient stands while being examined, is added to the equipment of some machines, and facilitates rotation for different angles of view.

FOOT-SWITCH

All screen work is done with a current ranging from 2 to 6 milliamperes controlled by a graduated foot-switch.

To operate, the main rheostat on the machine is set to the maximum desired for screen work, and this maximum is admitted to the screen tube by the third pedal of the foot-switch. There are two other pedals which admit respectively one-third and two-thirds of the maximum current, the regulation being effected through an auxiliary rheostat to which they are connected. We are accustomed to using approximately 6 milliamperes as the maximum, 4 milliamperes for the intermediate, and 2 milliamperes as the minimum. These readings, however, will fluctuate somewhat according to the resistance of the tube.

The graduation by the foot-switch permits the operator unassisted to proportion the current to the thickness of the patient and thus to give the intensity of illumination desired. This arrangement diminishes the likelihood of overheating the ordinary gas tube, and its convenience is obvious.

In addition to the current-control a light-circuit is led into the foot-switch and attached to a make-and-break switch which controls the subdued illumination of the room between examinations. This light is also turned on and off by the operator's foot. The single pedal foot-switch is less complicated and is entirely satisfactory and practicable.

TUBE-STAND

If a combination-table is not available, some form of tube-stand may be used for plating the stomach either in the vertical or horizontal position. An ordinary table can be used for the horizontal position and a frame-work for holding the cassette can be fastened against the wall for the vertical position.

TABLE

Trochoscopes and combined tables for roentgenoscopic and roentgenographic work are obtainable in various designs. One of these tables, designed for routine service, suits our own work admirably.

The table-top is of standard make, tunnel type, with celluloid window and standard stereoscopic plate-shifting mechan-

ism. The top is supported by an iron frame, largely of tubular construction.

A vertical tube-stand is carried upon horizontal rods attached to the back of the table, and is fitted with ball-bearings so that it can be easily shifted. By means of a lock it can be fixed in any position. The tube-holder is of the usual type with a lead-glass, bowl-shaped container secured to a metal base-frame, and can be raised, lowered, tilted to any angle or rotated upon its horizontal axis.

The table has been further amplified by placing a movable tube-box beneath it for horizontal screen-examinations. The tube-box and adjustable diaphragm are similar to those used on vertical screen-apparatus. The box shifts laterally on a frame, and the frame and box can be moved lengthwise on a tubular track, with ball-bearings for all moving parts.

The arrangement thus permits the use of two x-ray tubes; one on the vertical tube-stand for making roentgenograms, the other in the tube-box for screen work, the tubes being maintained at vacuums appropriate for their respective purposes. By a unique coupling the tube-box carriage and the vertical tube-stand can be linked together and moved in unison, so that the screen-field can be plated quickly by swinging the upper tube into place and by changing the overhead two-way high tension switch. This table may be employed also for general roentgen work. If plates 10×12 inches or larger are used it will answer for plating the stomach, duodenum and colon, but if plates 8×10 inches are used for the stomach and duodenum, the Cole table or some modification of it is desirable for localization.

TUBES

For plate-making various types of ordinary gas tubes may be employed. Greater differences as to quality and durability are observed between individual tubes than between types. Preferably they should have a heavy copper anode faced with tungsten. For screening, we have used water-cooled tubes but

more recently we have used the hot cathode tube for this purpose and have found it far superior. It will operate continuously and the penetration can be varied at will.

Coolidge has developed a tube of extraordinary efficiency. It is exhausted to a much higher degree than the ordinary tube. The cathode is a tungsten filament in the shape of a flat, closely wound spiral, and is heated by current either from a storage battery or a small transformer, with rheostat control. The storage battery can be used whether the main current supply is direct or alternating, but in the latter case, some form of rectifier is necessary for recharging the battery. The small transformer is of use only with the alternating current, but if the source of current is direct a rotary converter must be employed in conjunction with a filament transformer. Electrons are liberated from the cathode in proportion to the degree of heat, and the tube penetration can thus be controlled with precision. This tube has displaced the gas tube for screening and therapeutic purposes, and is coming into common use for making roentgenograms. It is very durable and seems to be ideal. Our own experience with it has been highly satisfactory. Recently a new form of Coolidge tube has been brought out by the General Electric Company. This tube has a radiator made of metal discs attached to the anode for cooling purposes. When operated at a certain milliamperage set by the makers it is self-rectifying and can be operated directly from a suitable transformer without a rectifying switch.

INTENSIFYING SCREENS

Intensifying screens are distinctly advantageous because they shorten the time of exposure. Fortunately, there are American screens quite as good as, if not better than, the foreign screens. In using the screen, cleanliness and careful loading, with firm contact between the plate and screen must be observed. The cassette should be of light weight, thin, durable, light-proof and easily loaded. Cassettes made of aluminum are preferable to those of wood.

PLATES AND DEVELOPERS

The best plates are those which have unvarying uniformity, fair latitude, moderate speed and good keeping qualities, and are free from blemishes. Reasonable latitude is desirable in order that slight variation in the time of exposure will not impair the roentgenogram. The greater the speed, the less is this latitude; hence it is better to choose a plate that is neither extremely fast nor extremely slow. Manufacturers recommend developers which are best suited for their plates, and their advice should be followed.

Questions are frequently asked as to the length of exposure necessary to produce a satisfactory roentgenogram. This depends, as the operator will soon learn, on the capacity of his machine, the voltage, the milliamperage passing through the tube, the speed of the plate, the tube distance, the density of the part and whether or not an intensifying screen is used. Therefore, the beginner should not hastily blame his equipment nor be surprised at his early failures, for they can be overcome only by experience.

CHAPTER II

GENERAL TECHNIC

In order that comparisons may be made on a uniform basis, the roentgenologist should have a customary routine. While it would be desirable for all roentgenologists to employ identical methods, efforts in this direction have thus far been fruitless. However, the individual examiner will find it advantageous to choose and follow as faithfully as possible the method which to him seems best. His routine should, of course, be flexible enough to vary in exceptional circumstances. Indeed, some degree of inventiveness and ingenuity is requisite in dealing with extraordinary problems, but in forming opinions allowance should be made for any departure from the accustomed procedure.

It should be kept constantly in mind that most of the conclusions herein stated are based on the routine described. Those who desire to follow the methods described should adhere with reasonable fidelity to the technic. Otherwise there may be annoying discrepancies in the results. On the other hand, it should also be emphasized that rigid adherence to any routine will not alone make diagnoses; that interpretation of findings, which can be learned only by experience, is quite as important as technical methods; and that the beginner must expect at least a few disappointments at first.

Preparation of the Patient.—One of the most important roentgenologic signs of a lesion in the digestive tract is deformity of contour, and such deformity may be imitated by the presence of spasm, food or fecal material. The stomach, when examined, should be empty; ample time should be allowed for evacuation of the last meal taken prior to the examination, and the patient should abstain from food until the examination is finished. The majority of patients come directly from the gastroenterologist after tubing and lavage, and while, as a rule, these latter pro-

cedures are not a necessary prelude, they insure a more thorough evacuation of food bits and secretion in obstructive cases, and clear out mucus and hemorrhagic detritus from the craters of gastric ulcers. If the colon is to be examined by the opaque clysma, the patient should be previously purged with oil or a saline, preferably oil, and should flush out the bowel with a cleansing enema shortly prior to the examination.

In exceptional instances where motility is especially concerned, as in cases of suspected stasis, a separate examination under the patient's accustomed conditions and without purgation, enemas or fasting, may be conducted. Such findings should be compared with each other, and not with those obtained after preparatory measures.

Opaque Salts.—In the early attempts at visualization of the human digestive tract, bismuth subnitrate was tried. Its occasional toxicity led to some fatalities and it was soon abandoned. Since then bismuth subcarbonate has been extensively employed. It has been claimed (and disputed) that its alkalinity somewhat depresses peristaltic activity. The oxychloride of bismuth, which is sometimes used, is a trifle lighter than the subcarbonate, and hence a little more easily held in suspension. Peristalsis, as seen with the oxychloride, is perhaps a trifle more active than that seen with the subcarbonate. Both the subcarbonate and oxychloride are harmless even in much larger quantities than ordinarily administered. The oxides of zirconium (kontrastin) and thorium, and the magnetic oxide of iron have been used to a limited extent.

Chemically pure barium sulphate at less than a tenth the cost of bismuth salts is equally satisfactory and is now generally employed. We have adopted it for both the opaque meal and the enema. It must be free from any soluble salts of barium which are poisonous; it should be in a finely divided state, and can be obtained in this condition from manufacturers. It is harmless, tasteless, and does not inhibit or unduly stimulate peristalsis, but is passed through the digestive tract more rapidly than bismuth salts.

Attempts have often been made to visualize the digestive canal after inflation with air or gas. Notwithstanding the fact that pronounced lesions have occasionally been demonstrated in this manner, the method is far less certain than the use of opaque meals and enemas, and hardly deserves serious consideration.

Vehicles.—In selecting a medium for the administration of opaque salts, a wide latitude of choice is offered. Any of the commonly used vehicles may be employed with satisfaction, but it is desirable that the mixture shall have the following qualities:

1. It should be palatable.
2. It should be sufficiently viscid to hold the opaque salt in good suspension.
3. It should not be too thick to fill small recesses.
4. It should not unduly stimulate gastric secretion.
5. It should neither accelerate nor retard motility.
6. It should have a temperature of about 70°F.

The vehicles commonly used include water, milk (plain, condensed or fermented), mucilage of acacia, potato-starch, bread-and-milk, corn-starch-pap, gruels and various cereals. Each of these has its advantages and disadvantages, depending on the purpose in view. For the six-hour opaque meal, a cereal, such as one of the wheat breakfast foods, is desirable. For the screen examination an aqueous solution consisting of 250 c.c. of water, 120 gm. of barium sulphate, 4 gm. of bicarbonate of soda, and 10 c.c. of syrup of raspberry is used. The soda neutralizes the gastric juice to some extent, produces relaxation of the pyloric sphincter, and enables the examiner to fill the duodenum readily by manipulation. The syrup of raspberry is added for flavoring. Thirty grams of sugar of milk will aid the emulsification, add to the palatability of the mixture and is mildly laxative. This aqueous mixture, when thoroughly agitated with a mixing machine (Fig. 1), will remain in good suspension for from ten to fifteen minutes. It is easily prepared, convenient, palatable, and it can be shifted into all

parts of the stomach, thus outlining its borders. Since it is of thin consistency, it will enter small ulcer craters and ulcer-pockets and is of especial advantage in visualizing the duodenum. If considerable time elapses between the screen examination and the making of plates, or if the stomach is unduly large, a second glass of the mixture may be necessary, or fer-

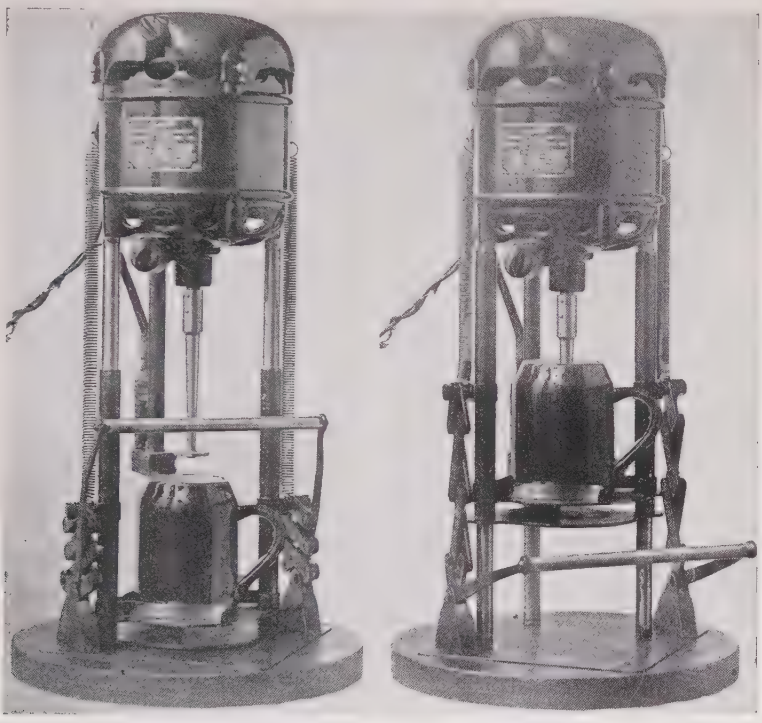

FIG. 1.—Two views of mixing machine.

mented milk, which may be obtained either in bottled proprietary form or made by adding culture-tablets to whole milk, is admirable. This is relished by most patients; it holds the opaque salt in good suspension, and does not affect the motor functions. Mucilage of acacia, freshly made from the powdered gum, is effective. It is especially useful in examining the esophagus. Condensed milk holds up barium fairly well and is palatable, but owing to its fat, markedly diminishes motor

activity. Thick gruels of wheatmeal or oatmeal are often used in esophageal work.

A pap made up either with potato-starch or corn-starch is an excellent vehicle. Both have been used extensively, the corn-starch is preferable because of its more pleasant taste, and it is obtainable everywhere in pound cartons. To prepare the pap in quantity the following recipe may be used:

Two hundred seventy grams of corn-starch dissolved in 420 c.c. of cold water is poured into 6 liters of boiling water. 1.350 kg. of barium sulphate is stirred into a thin paste with 600 c.c. of hot water; allowed to boil for three or four minutes, and is then added to the starch-pap. The whole mixture is stirred well and allowed to boil for five minutes slowly. After cooling, 15 c.c. of vanilla extract is added. Syrup of raspberry in larger quantity, or other flavoring, can be used as desired. The mixture will keep well on ice for two or three days. On standing a scum may collect; this should be removed. The customary portion for each patient is 360 c.c. of the mixture, which amount contains approximately 90 gm. of barium.

The Enema.—The essentials of an opaque enema are:

1. That the mixture shall not be irritating to the bowel.
2. That it shall be sufficiently large to fill the entire colon.
3. That it shall be sufficiently fluid to flow freely, yet thick enough to keep the barium (or bismuth) well distributed.
4. The temperature should be from 100° to 110°F.

Any of the opaque salts may be used as a base but the inexpensive barium sulphate is employed most generally. In some instances bolus alba (kaolin) is added, 500 gm. to 1.5 liters of water.

For mediums, mucilage of acacia, fermented milk, condensed milk, mucilage of tragacanth, starch and other vehicles are employed. Any of these or combinations of them can be used satisfactorily. The starch solution has the occasional disadvantage of becoming lumpy on standing and thus obstructing the enema tube. A combination of mucilage of acacia, condensed milk and barium (described in the chapter on The Large

Intestine) is the one used by the writer and makes an excellent enema.

Quantities.—The quantity of opaque salts used for the meal by different roentgenologists varies markedly, ranging from 30 to 180 gm. at a single administration, and the total amount of ingesta may be from 180 to 900 c.c. The proportion by weight of opaque salt to medium varies from 10 to 25 per cent. As a general rule, it will be found that mixtures containing less than 10 per cent of the opaque salt, especially barium, are not reliable for visualizing lesions on the screen or plate.

There are wide differences among various examiners in the manner and time of observation. One routine frequently employed consists in the administration of a single opaque meal, the phenomena of its progress through the digestive canal being noted at successive intervals by screening and plating. By the double-meal method as used by Haudek,[1] which I have preferred to follow, one meal is given chiefly for the purpose of testing motility, and this is followed by another meal six hours later, at which time the roentgenologic examination is made.

The Six-hour Meal.—As employed by Haudek, the six-hour meal was made up originally with bismuth subcarbonate. Haudek's wide experience convinced him that a distinct residue from this meal in the stomach after six hours was usually of pathologic significance, although, in some instances, he believed it might result from gastric atony. For seven years or more I have used a modification of the Haudek six-hour motor meal. It consists of 60 gm. of barium sulphate in 60 gm. of any cooked wheat cereal to which a little skimmed milk and sugar are added. Since barium leaves the stomach earlier than bismuth, and since carbohydrates are the first foods to leave the stomach, a residue from this bariumized carbohydrate meal has even greater import. Of course, it is to be understood that I do not make diagnoses on six-hour retentions. However, it is a very valuable contributory finding since 95 per cent. of all residues from this meal indicate a lesion either in the stomach or just

beyond. Objection has been made that in those cases in which the six-hour meal has advanced into the transverse colon or splenic flexure it may interfere with the screen and plate examination of the stomach. This seldom happens and since lesions of the greater curvature of the stomach are very rare, barium in the transverse colon can hardly be a serious objection. If barium in the hepatic flexure interferes with the examination of the duodenum, as it sometimes does, a second examination may be made without the six-hour meal and always has its advantages. Personally, I would rather risk the necessity of a second examination than do without the motor-meal.

The principal advantage of the six-hour meal is the saving of time to the examiner and of annoyance to the patient entailed by repeated screening or plating. It not only shows whether the stomach is able to clear itself within the given time, but also by its position and distribution in the intestine gives gross information as to intestinal motility. Its use is based on the theory that the exact emptying-time of the stomach is less important than the fact that a liberal time-limit for evacuation is, or is not, exceeded. It is quite possible that a more refined study of the gastric clearance-time will be of greater diagnostic aid. In estimating the significance of slighter variations in the time of emptying, however, the numerous physiologic and pathologic factors affecting motility will need to be carefully weighed.

The time limit of six hours is not accurate when the examination is begun with a full stomach and the patient is again examined in six hours to see if there is any residue. A much larger percentage of residues will be found than with my modification of Haudek's motor meal, and many retentions will be present in the normal stomach. To have an equal value for showing pathologic lesions the time-limit would have to be increased.

The Screen-examination.—I believe that the advantages of the screen in the examination of the digestive tract can hardly be too strongly emphasized. Only by its use can exact information be obtained as to mobility and flexibility, the phenomena of

peristalsis and antiperistalsis, the nature and permanence of irregularities of contour, and the effects of palpation, respiratory movement and varying positions. All changes can be seen at every instant, in the order of their succession, at any desired angle, and in these respects a few minutes of screening is equivalent to hundreds of plates. The screen also affords convenient opportunity for inspecting the chest and abdomen for numerous lesions which may affect the digestive tract reflexly.

A very necessary part of roentgenoscopic technic is the proper preparation of the observer's eyes. To secure dark-adaptation the examiner should be in the darkened screen-room for from fifteen to twenty minutes before beginning his work. The maintenance of this accommodation is furthered by the use of subdued illumination whenever light is required at intervals, and the use of smoked glasses during these periods. For the room-light a color in the red portion of the spectrum is preferred,[2] and is best secured indirectly by reflection from a tinted ceiling. The walls may be finished in the same color.

Male patients should be stripped to the hips. Women may be allowed to wear a kimona of thin material, but this should be devoid of buttons or ornaments, and the underskirts should be dropped below the abdomen.

Palpatory manipulation is a very essential part of the roentgenoscopic procedure and should never be omitted. Not infrequently the patient, made apprehensive by his somber surroundings, tenses his abdominal muscles so that palpation is ineffective. This difficulty can usually be overcome by quieting the patient's fears. He should also be required to bend his head forward, drop his shoulders, allow his arms to hang limply, and breathe deeply with open mouth. If the amount of relaxation desirable for proper palpation of the stomach is not obtained in this manner, the patient may be allowed to sit down for a few minutes while others are being examined. If all these procedures fail, as sometimes happens, sedatives or antispasmodics may be given before the second examination is made.

Mindful of the numerous disasters which have befallen the pioneers in roentgenology, many have a lively sense of possible danger to the operator from the use of the screen. I can say only that after several thousand examinations with the apparatus heretofore described, I have experienced thus far no evil effects.

The tendency of the rays to produce sterility is well known, and perhaps may not be overcome by the usual protective measures if exposures are long or frequently repeated. Certain blood-changes also have been noted by Portis[3] and others. But workers with the ray who take the customary precautions are not likely to develop roentgen dermatitis or carcinoma. The operator should endeavor to secure the greatest amount of protection consistent with efficiency. He should wear gloves of leaded rubber or other opaque material, and should protect the genitalia with an apron of leaded fabric. If, with all these measures, he is still dubious of his safety, he should test for leakage with radiographic films, plates or pastilles.

As for the patient, his safety is fairly assured by the protective features of the apparatus and by the brevity of the examination. With reasonable care as to the character of the tube (say one backing up 12 to 15 cm. on the parallel spark-gap at 5 milliamperes), with a suitable filter, and an exposure of ten minutes or less, no patient will be harmed. Four or 5 milliamperes on the tube-circuit will usually suffice, but for thick patients 6 or even 7 milliamperes will give a better image.

The time necessary for roentgenoscopic investigation of the stomach and duodenum will not usually exceed five minutes, depending on the experience of the examiner and the condition of the patient. Occasionally, however, when peristalsis especially is to be studied, a little more time will be required. By judicious use of the foot-switch, turning on the rays only as needed, the aggregate of exposure can be considerably lessened.

Plates.—After the examiner has acquired some proficiency with the screen, he will occasionally be inclined to dispense with

plates, especially in the apparently normal case in which the patient is thin, the screen image sharp, and the clinical history negligible. But it is never wholly safe to do this, and at least two or more plates should be made in every case. Plates show minute deformities which cannot always be detected on the screen, may be studied at leisure, and may be filed for future reference. When the result of an examination is indecisive it has been found that repeated screen examinations are of greater value than are an increased number of plates. However, if multiple plates are preferred to repeated screen examinations they are useful in a study of the stomach, the pyloric region, and the duodenum. They can be made either in rapid succession or at longer intervals.

Lewis Gregory Cole,[4] has elaborated the multiple-plate method and applied to it the term "serial radiography." He employs a table equipped with a fluoroscopic screen and a plate-changing device beneath the table-top which permits the making of multiple plates without disturbing the patient. Besides, the operator can observe the stomach on the screen and make a plate at any desired moment.

In published discussions of gastric roentgenology it is occasionally intimated that the screen and plate are rivals. This is a misapprehension. Rather should they be considered as indispensable complements of each other in every complete examination. I have always used both methods, and would fear to discard either. Cases are frequently met with in which sometimes one, sometimes the other, alone elicits the information sought.

The positions employed for particular purposes, suitable sizes of plates, and other details are described elsewhere. I find some advantage in the intensifying screen and use it regularly. But as to this and many other technical refinements, such as the kind of tube, the tube-distance, the milliamperage, length of exposure, etc., no hard and fast rules can be laid down, and every roentgenologist determines these things according to his own judgment and the character of his equipment.

Stereoscopic plates are striking in their appearance and are somewhat more informative than single roentgenograms, but they are rather superfluous if a careful screen examination is made.

Roentgen kinematography has been tried in a few instances with fairly satisfactory results. It is not practicable as a routine and does not possess any extraordinary advantages over roentgenoscopy.

Records.—The benefits derived from a systematic record of case observations more than compensate the examiner for the time required to register his findings, no matter whether he sees 1 or 20 cases a day. Such a system not only keeps the material in shape for ready comparison, but promotes orderly thoroughness of observation, thus preventing the errors often consequent on haphazard investigation.

Besides the usual series of card indices, the roentgen records consist of a fluoroscopic sheet, a permanent record sheet and a recapitulation sheet. The sheet which is used in the screen-room (Fig. 2) has a brief form for the entry of the gastric analysis and the screen findings. Most entries can be made simply by checking or underscoring the item.

In the blank square the examiner notes his diagnostic opinion or the most significant facts. Subsequently, the notations on this sheet are compared with the plate findings, and a final report is entered on the permanent record sheet.

The permanent record sheet may seem rather elaborate and cumbersome, but it can easily be filled out as nearly all the data may be entered by underscoring (Fig. 3). Some of the items are seldom used, but have been included in order that the record may cover a wide range of possibilities.

The diagnostic division provides for an abbreviated cipher of the diagnostic opinion. Pathologic conditions are denoted by numbers and the parts involved by capital letters. By combining a number and a letter the diagnosis can be condensed within small space. (See "Note" on permanent record sheet, Fig. 3.)

Before each item in the body of the sheet is a small letter.

FLUOROSCOPIC SHEET.
MAYO CLINIC.

Case No. A..... Sex..... Age..... Date.....

Name.....

Chemical
- Total Acidity
- Free Hcl
- Comb. Acids
- Lactic Acid

Microscopic
- Food remnants
- Oppler-Boas
- Yeasts
- Sarcinæ

Habitus N. E.

Residue O. 1. 2. 3. 4.

Head I. C. H.F. T.C. S.F. D. S.

Peristalsis Nor. Active Vigorous Not Seen

Bulb Seen Size 1 2 3 Reg. Irreg. Not Seen

Duod. Visualized Immediately Delayed Not Seen

Antrum Seen Regular Irregular Not Seen

Mobility Free Slightly Fixed Fixed

Filling-Defects Card Media Pylorica GC. LC.

Incisura Card Media Pylorica Transient

Hour-Glass Stomach Organic Intermittent

Tender Point L.C. Duod. G.B. McB. Epig.

Niche

Diverticulum

Operations

FIG. 2.—Scratch sheet for fluoroscopic findings.

If the item is underscored, this letter is entered in the corresponding column of the recapitulation sheet.

The recapitulation sheet facilitates a rapid summary of case findings (Fig. 4). By tracing a single column on this sheet the percentage of occurrence of a given observation can readily be found; thus also the incidence of various combinations can be determined quickly.

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SHEET A. PAGE..... YEAR..... DIGESTIVE TRACT, X

	CASE NO.	NAME	AGE	PARTS EXAM.	DIAGNOSIS				ESOPHAGUS				
	1	2	SEX	3	4	5	6	7	8	9	10	11	12
						Extent Int.	Confirmation	Habitus	Position	Patency	Peristalsis	Tonus	Filling Defect
1													
2													
3													
4													
5													
6													
7													
8													
9													
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FIG. 4.—Recapitulation

-RAY

16-1617-W

	STOMACH							PYLORUS				DUODENUM						
2	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
	Form	Position	Size	Mobility	Peristalsis	Incisura	Evacuation	Position	Mobility	Patency	Opening	Visualization	Position	Mobility	Patency	Peristalsis	Bulb	
																		1
																		2
																		3
																		4
																		5
																		6
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sheet.

	JEJUNUM & ILEUM		C.V	APP.	COLON						RECTUM	TEST BREAKFAST								PREVIOUS OPERATION	
	30		31	32	33	34	35	36	37	38	39	40				41				42	43	44
	Patency	Peristalsis	Competence	Visibility Lumen	Position	Mobility	Patency	Peristalsis	Miscellaneous	Observation	Patency	Total Acidity	Free Hcl	Combined Acid	Lactic Acid	Blood	Food Remnants	Sarcinea	Oppler-Boas	Antispasmodics	Specimen Photographs	
1																						
2																						
3																						
4																						
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FIG. 4.—Recapitulation sheet

-F. X-RAY SHEET B. PAGE..... YEAR.....

16-1617-W

OPERATIVE FINDINGS 45	REMARKS 46	
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		14
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		25

continued.

CHAPTER III

INTERPRETATION

The roentgenologic examination of the digestive tract is not a mysterious art requiring extraordinary talents. Neither is it a simple diagnostic method which can be learned in a day. Its successful employment demands industry, experience, judgment and care, just as any other procedure in medicine—no more, but no less.

The roentgenologist has to deal with shadows and shadow defects as signs of normal, reflex and pathologic conditions. These signs vary in their frankness and degree. Some of them are more or less direct, showing as definite and permanent additions to or subtractions from the normal contour. Others are rather indirect, revealing only perversion of function, and the seat and nature of the pathologic change can only be inferred. Indirect signs have different values at different times, singly and in combination. It is impossible to put into words the exact worth of these signs in their fluctuating grades. That can be learned only by actual experience with adequate material and by following cases to the operating room and the post-mortem table. The most painstaking description of a lesion is not equivalent to seeing it oneself in the opened belly, and only by this sort of vision can one obtain a proper understanding of roentgen diagnosis or confidence in the method. Familiarity with reflex conditions and the protean forms of spasm is absolutely essential.

The maintenance of a conservative attitude in this work is especially necessary, and, at the same time, especially difficult. The veteran roentgenologist, as well as the novice, is tempted to see too much rather than too little. Once the observer has acquired some familiarity with his work he will find that direct

signs of lesions will be manifest quickly or not at all. He should, of course, take sufficient time to examine his patient in all the routine particulars, but unduly prolonged examinations dull the sense of perception, and a perfectly innocent stomach may seem guilty to ungenerous scrutiny.

Failure to discover a lesion by the roentgen-ray is often pardonable, but the subjection of a patient to needless operation on trivial roentgen evidence alone, is not readily forgiven by those concerned. Common sense has been defined as the ability to distinguish the important from the unimportant, and in this meaning every diagnostician has an abiding need of common sense.

There are two very practical checks against error which the examiner may employ, namely, reëxamination and the giving of antispasmodics in cases in which spasm is suspected. In all doubtful cases one or both of these tests should be applied.

By any means of diagnosis, exceptional cases are found which are quite at variance with the common rule. Naturally, these are tremendously impressive, so impressive that it is difficult thereafter to avoid being unduly alert for them. The only safe way is to hold fast to the rule and regard exceptions with doubt.

The statement of W. J. Mayo, that only about one person in ten with gastric symptoms has a gastric lesion, is worth remembering. The beginner is likely to be disappointed by the multitude of cases in which he is unable to find any roentgenologic evidence of a gastro-intestinal lesion, and will often feel that he is at fault. But besides a percentage of patients with such lesions which no one is as yet able to discover, there will be a much larger number of patients whose symptoms are produced by conditions outside the digestive tract. Extrinsic conditions giving rise to abdominal symptoms are sometimes discoverable during an examination of the alimentary canal. The observer should keep in mind the possibility of aneurysm, pleural, pulmonary, mediastinal and cardiac disease, diaphragmatic hernia and eventration, subdiaphragmatic abscess, gall-stones, renal,

ureteral and vesical stones, enlargements and tumors of the kidney, spleen, liver and pancreas. He should watch, at least casually, for vertebral disease, for fractures and deformities; in short, for every abnormality, and report it whether it may or may not have any relation to the patient's complaints. To be sure, gall-stones and stones in the urinary tract are likely to be overshadowed by the barium and discovery of them will be only fortuitous, but if their presence is suspected they should be looked for at a separate examination.

The hazard attending diagnosis based exclusively on plate findings, especially when the plates are few in number, deserves particular stress. Plates show but a single phase and a single angle of view. Artefacts which may be produced in countless ways cannot be distinguished from physiologic and pathologic images with any degree of certainty if only one or two plates are made. Yet, when used as a complement to the screen, the plate may give substantial aid, and it should be employed in that manner only.

How shall the examiner report his findings? How far shall he go in translating them into terms of diagnosis? This depends on his relations to the clinician, the acquaintance which each has with the other's province, and whether the work is done in an organized institution or independently. An ultra-conservative method would be simply to report the bare facts of the observation—a shadow here, a filling-defect there, a residue, or whatever is seen—and leave all diagnostic interpretation to the clinician. To be wholly satisfactory this would necessitate an extent of organization which has not yet been reached, and few clinicians understand the precise significance of roentgenologic indications. For this reason verbose reports of all the roentgen phenomena observed in a given case are worse than useless because they may mislead the clinician, and a simple statement of the conclusions formed would be far better.

Another way would be for the roentgen examiner to restrict his diagnoses to those cases in which the roentgen signs alone are pathognomonic. For instance, if the lesion is a niche a

definite diagnosis of ulcer can be made. If there is a filling defect in the contour of the stomach which corresponds to a palpable mass the examiner can say that a tumor is present and since 95 per cent. of all tumors of the stomach are malignant he is safe in saying that it is carcinoma. Certainly he can perform valuable service in this manner; but what of the cases in which the roentgen signs, though definitely abnormal, are not definitely diagnostic and yet may corroborate a clinical picture? As a concrete illustration may be cited the occurrence of a six-hour gastric residue with prepyloric irregularity, phenomena which are definitely abnormal but which alone are not sufficient to maintain a diagnosis either of ulcer or cancer. In other words when the roentgen signs can not be expressed in definite terms of a diagnosis, it is better to state that a lesion exists, than to attempt to guess its pathology. Yet these signs when combined with the clinical facts, may point rather directly to the nature of the lesion.

Extreme limitations of diagnostic latitude are not truly conservative, but they are reactionary, and would seem to rest on the assumption that a diagnosis is a statement of fact, not an expression of opinion. Yet every diagnosis implies the exercise of opinion and the rendition of judgment, and even the pathologist, who has the last word in this respect, is not infallible.

It is less important that we be solicitous regarding artificial rules which we may impose on ourselves—as though a game were being played—than that we remember the rights of the patient. It is his just due that all features of his condition shall be properly weighed, not only separately but also in their relations to each other and as a whole.

It follows, then, that somewhere and somehow the roentgenologic findings should be correlated with the clinical as well as all other data. How shall this be done?

1. It may be done by the clinician. This implies a broad knowledge on his part of roentgen diagnostics, which can be acquired only after years of experience. Reduced to practical terms it means that it would be better for the clinician to make

his own roentgenologic examinations. Possibly this is the ultimate solution.

2. The clinician and the roentgenologist may make a joint examination, or go over their respective findings at a personal conference. Active coöperation would certainly be preferable to the customary passive combination of their work.

3. The roentgenologist himself may correlate his findings with the clinical and other data. Under present conditions this is perhaps the most practical and efficient method. As a medical man he should have little difficulty in refreshing his knowledge of symptoms, laboratory reports, and at least, gross physical signs. By so doing, his work will rest on broader foundations, and not only will his interpretations be tempered by the clinical data, but he will also acquire a more exact sense of purely clinical values.

The clinical data may be used:

1. In combination with the roentgen observations to form a general complex on which the diagnosis is based.

2. As an index of the possibilities and probabilities in the case at hand and thus direct the examiner's particular attention to them.

3. To prevent too hasty judgment, as in those cases in which the roentgen signs do not harmonize with the clinical facts, and in which a more careful review of these signs or a reëxamination may show them to have been mistaken.

It has been suggested that clinical data may unduly prejudice the roentgenologist and give bias to his verdicts. This could occur only on condition that his experience has not been sufficient to teach him the relative value of signs, either roentgenologic or clinical. Because of the various influences affecting the gastro-intestinal tract which may lead to diagnostic error such as spasm, tonus, fright, anger, or muscular contraction, I pay no attention to the clinical signs, but make a report of the roentgen findings insofar as the manifestations will permit. While this independent method of examination has given greater accuracy in the diagnosis of gastro-intestinal

diseases, it does not hold true in other parts of the body, where these influences cannot be brought to bear. In such instances vague roentgen findings may be clarified by a correlation with the clinical data or vice versa.

To sum up, the essentials for satisfactory roentgen diagnosis are faithfulness to an orderly routine, careful observation, the use of antispasmodics and reëxamination in doubtful cases, cautious interpretation, and last, but not least, a willingness to admit whenever it is true, that the findings are inconclusive.

CHAPTER IV

THE ESOPHAGUS

Technic.—While in most cases no special preparation of the patient is necessary for an examination of the esophagus, there are cases of obstruction in which retained food or secretion may interfere with the examination or impair the accuracy of its

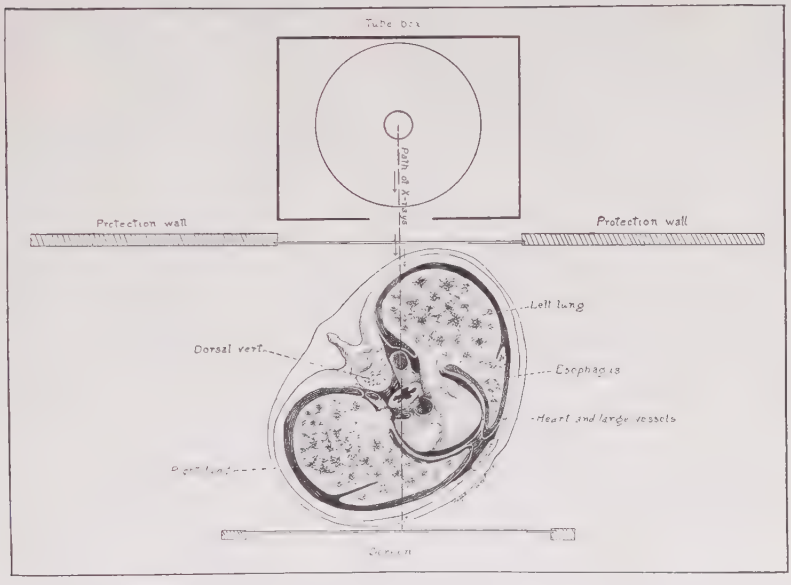


FIG. 5.—Cross-section diagram showing position of the esophagus relative to other organs in the oblique view.

results. Whenever such conditions are suspected it is advisable to have the gullet cleared out either by the voluntary efforts of the patient or by tubing and lavage.

Standing with his back to the tube and with the screen against his chest, the patient should first be given a general survey in the anterior position. With the diaphragm widely extended, the entire chest should be inspected, attention

being given to the supraclavicular regions, the lungs during forced respiration, the excursions of the diaphragm, and the size and position of the heart and aorta.

The patient is then turned to an angle of about forty-five degrees so that his left scapula is directed toward the tube, while the screen hangs over his right chest. In this position, the right anterior oblique, the rays pass through the patient obliquely, as shown in the cross-section diagram (Fig. 5). The esophagus, with the sole exception of its short subdiaphragmatic portion, can thus be studied to best advantage. Particular attention should be paid to the retrocardiac space, the clear area lying between the spine, heart and large blood-vessels. Encroachment on this space should suggest the possibility of aneurysm or mediastinal tumor. The drawing illustrates the normal relations (Fig. 6).

The exact angle desired can rarely be obtained beforehand, but, while looking on the screen, the observer can rotate the patient slightly in either direction until the greatest space is attained between the shadow of the vertebral column behind and that of the heart and aorta in front. The horizontal leaves of the diaphragm are extended to their limit, while the vertical leaves are approximated until only the esophageal region is in the visible field. Screens of average size will not accommodate the whole extent of the esophagus, and hence require raising and lowering in order to cover the entire course. Besides, for clear vision and to avoid distortion, it is better to have a small field with the tube and screen in the plane of any point which is to be closely scrutinized.

After the patient is satisfactorily posed he is given a barium-acacia mixture, a teaspoonful at a time. This is prepared by mixing four parts of barium sulphate with one part of fresh mucilage of acacia, as described by Hirsch,[1] who, however, prefers bismuth to barium. When first mixed it is rather dry and granular, but by continued stirring becomes smooth and homogeneous. A total of from 2 to 4 dessertspoonfuls is all that is necessary. The resulting mass is exceedingly viscid.

It descends the esophagus slowly and tends to coat its walls throughout. Each bolus is followed in its progress downward. For additional observation the patient is given a few spoonfuls of a mixture of barium sulphate and cooked breakfast cereal, equal parts. This can be swallowed in larger quantities than the acacia mixture and shows the distensibility of the esophagus somewhat better. If the esophagus is markedly dilated above an obstruction, greater amounts of bariumized

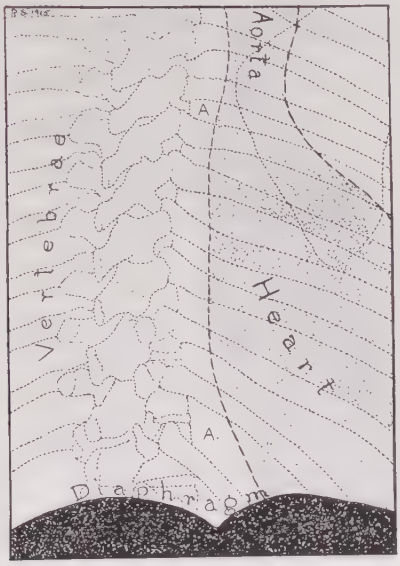


Fig. 6.—Diagrammatic view, right anterior oblique position. *A*, *A*, retrocardiac space.

cereal or the aqueous mixture are given to show the extent of dilatation.

The anterior position, the patient facing the observer squarely (or at a very slight angle) is desirable for inspection of the subdiaphragmatic portion of the esophagus and also for determining the position of lateral diverticula.

In making roentgenograms it is better to select that position which during the screen examination showed the conditions to best advantage. For the oblique view, the plate taking the

place of the screen should have the same degree of obliquity (Fig. 7). Plating in the anteroposterior view (Fig. 8), with the patient's back against the cassette, is advantageous for showing lesions of the epicardia. Plates 11 by 14 inches, or 14 by

FIG. 7.—Patient in right anterior oblique position for roentgenography of the esophagus.

17 inches, should be used with the intensifying screen, and with the tube at a distance of from 50 to 75 cm. from the plate. By using a small cone and small plate, lesions which have been located exactly can be shown with better definition. Many

prefer to make plates with the patient recumbent, and we often make them in this way.

Variations of technic, both in screening and plating, can be improvised to suit the circumstances of the case. The left

Fig. 8.—Position of patient for roentgenography of the epicardia. A small cone should be used to secure good definition.

posterior oblique position, which is the reverse of the right anterior oblique, or the posterior position, the patient facing the tube, are occasionally employed. Lateral positions, either

right or left, are sometimes satisfactory if the patient is not too broad-chested.

Different media may be used, such as fermented milk, bread-and-milk, or any sort of porridge. The use of barium or bismuth in capsules for determining obstruction is not advised. Capsules, whether large or small, behave as foreign bodies in the esophagus, they are swallowed with difficulty as a rule, and may lead to an erroneous diagnosis of obstruction.

In 1912 Myer and the writer[2] demonstrated the persistence of dilatation years after symptomatic cure of cardiospasm. They employed for the demonstration a thin rubber bag tied over the end of a rubber tube. The bag-tipped tube was passed down to the cardia and then filled with a bismuth mixture injected through the tube by a syringe. By this means the dilatation could still be observed, both on screen and plate, though obstruction had ceased.

Later, Bassler[3] made use of the bag-tipped tube, which was passed into the stomach, filled with water, and pulled up into the cardia, thus blocking it. The esophagus above it and outside of the tube was filled with a bismuth suspension in order to determine the presence of irregularities and lesions in the esophagus which were not sufficiently stenosed to show signs with the ordinary technic. The method occasioned considerable discomfort to the patient and caused retching and regurgitation. The bulkiness of the bag and tube made it difficult to pass it through small strictures and, on the whole, the procedure was unsatisfactory.

Crump[4] employs sausage-skins, as cleaned and prepared for packing houses, which he keeps in a solution of 1 per cent. liquor formaldehyd and 10 per cent. glycerin. The distal end is tied with a piece of silk floss so as to make a bag. The proximal end is slipped over a rubber tube and tied. The empty bag is practically only a string, and, with the aid of a little water, is swallowed by the patient, after cocainizing the pharynx if necessary. The bag is then filled through the tube from an irrigator with a bismuth emulsion, and the roentgenographic examination is made. The skins are easily obtained and

it is claimed that by this method the exact extent of involvement can be seen, and that early as well as late lesions can be outlined. It is claimed that the method is especially applicable to non-stenotic conditions.

In many instances it is advisable to supplement the esophageal examination with an examination of the stomach to elucidate the symptoms complained of. In this event the patient should have the usual preliminary preparation for gastric examination and should be examined in the horizontal position, either supine or prone, or even in the Trendelenburg position, for lesions high in the cardiac portion of the stomach.

The roentgenologist must expect frequent negative results, even in patients whose history is fairly emphatic. Some of the patients are perhaps merely neurotic; in others the trouble is spasmodic and intermittent, and in these an examination is usually negative unless it is made during an attack. Repeated examinations are often necessary to show intermittent stenotic conditions and to differentiate them from organic and permanent obstructions.

Interpretation of esophageal findings, unless they are extraordinarily typical, should be made cautiously. If the examiner is not thoroughly acquainted with the clincial facts in the case, he had better report simply what he sees without attempting to translate his observations into a diagnosis. He may say, for example, that obstruction of a certain degree was noted, with or without irregularity of contour at a certain point, or he may report whether or not there is evidence of a lesion outside the esophagus. The information may be associated by the clinician with his own data and a conclusion formed. This caution is necessary because of the frequent roentgenologic similarity of various esophageal lesions.

ANATOMIC MEMORANDA

Directly after its beginning (the introitus at the cricoid cartilage), the esophagus swerves to the left so that it projects slightly beyond the left border of the trachea. Above the bifur-

cation of the trachea it is pushed to the right and somewhat posteriorly by the aorta. Passing behind the beginning of the left bronchus it descends with the aorta which it half entwines so as to lie in front of the aorta just above the diaphragm. Running obliquely to the left, it passes through the diaphragm at the hiatus œsophageus, which is about at the level of the tenth dorsal vertebra, and thence continues very obliquely to the left into the stomach. The average total length of the esophagus is about 25 cm., of which 3 to 5 cm., the epicardia, lies below the diaphragm. The caliber is somewhat irregular, one investigator having noted thirteen slight constrictions in its course. The anatomic points of narrowing that are of chief importance are as follows:

1. At the introitus.
2. At the aortic arch.
3. At the crossing of the left bronchus.
4. At the hiatus œsophageus.
5. At the cardiac opening.

The entire epicardia is distinctly narrower than the rest of the esophagus.

THE NORMAL ESOPHAGUS AS SHOWN BY THE ROENTGEN-RAY

Movements.—The act of swallowing, as seen with the x-ray, may be divided into two phases, a pharyngeal and an esophageal. In the first phase the bolus is passed back into the pharynx by the tongue, the intrapharyngeal pressure is increased by contraction of the muscles of the pharynx until the introitus relaxes, and the food is forced into the esophagus. In the second phase the bolus passes rapidly down the esophagus to the cardia, is held there momentarily, and then enters the stomach. The rate and manner of descent vary considerably with the consistence of the bolus, its size, form, taste and temperature. The time required to complete the act of deglutition varies all the way from two to ten seconds. Fluids descend quickly, while solids travel slowest. Thin fluids go

down in an almost continuous stream; thick fluids and semi-solids are broken up into detached finger-sized masses. The latter, as a rule, hesitate at the narrowings mentioned, especially at the introitus, the crossing of the left bronchus and the cardia. According to some observers, the delay at the cardia consumes about half of the total time required in a single act of swallowing.

Peristalsis.—The fluidity of the media customarily employed, the rapidity of the act of deglutition and the numerous anatomic irregularities of the esophagus combine to make the detection of peristalsis difficult. The propulsive effect of pharyngeal constriction at the commencement of deglutition and the influence of gravity, especially as shown by the behavior of fluids in the esophagus of a standing patient, add to the complexity of this function and the difficulty of its analysis. However, esophageal peristalsis is frequently observed under both normal and abnormal conditions. According to Holzknecht,[5] the peristaltic wave occurs as a constriction ring about 1 cm. broad, driving the ingesta before it. Its speed has been stated as 2.5 cm. per second. Like that of the stomach, peristalsis of the esophagus is subject to numerous normal and abnormal variations in force and frequency, but aside from the exaggeration of peristaltic activity seen in stenotic conditions, cardiospasm, for example, and reverse peristalsis as noted in obstructive cases, these variations are seldom seen or regarded.

THE PATHOLOGIC ESOPHAGUS AS SEEN WITH THE ROENTGEN-RAY

Displacement.—Displacement of the esophagus in its course may occur as a result of aneurysm, pleural, pulmonary or mediastinal inflammations, mediastinal tumor, substernal thyroid, vertebral diseases or deformity, or cardiac enlargement. Displacement by an intrinsic lesion is relatively rare, although a filled diverticular sac may push the esophagus aside.

Deformity of Contour.—Irregularities of contour may be produced either by extrinsic or intrinsic conditions. Localized

filling defects may result from the pressure of an aneurysm or a mediastinal tumor. Retained food-bits in obstructive cases may produce irregularities resembling those of a new growth. The principal intrinsic lesions which alter the esophageal outline are carcinoma, benign stricture, cardiospasm and diverticulum. Unless there is rather marked stenosis, minor indentations of the esophageal wall will hardly be visualized during the brief transit of opaque media. In any event, the numerous slight normal irregularities must be borne in mind. The deformity of contour produced by a diverticulum, showing as a pouch-like addition to the esophageal lumen, can hardly escape notice.

Obstruction.—Stenosis is evidenced by retardation of the opaque medium in its passage through the esophagus, by visible narrowing of the lumen, sometimes by evident dilatation above the strictured area and occasionally by exaggerated or reverse peristalsis. The degree of retardation will depend somewhat upon the fluidity of the medium employed as well as the tightness of the constriction. Opaque capsules should not be used, for reasons previously mentioned. In seeking evidences of obstruction the following factors should be taken into account: (1) the slight delay often noted normally at the introitus, (2) the point at which the esophagus crosses the left bronchus, (3) delay at the cardia, and (4) the physiologic factor affecting the rapidity of the descent. With high seated stenosis regurgitation of the medium may interfere with visualization.

The usual extra-esophageal causes of obstruction are aneurysm, mediastinal inflammation and tumor. Other extrinsic conditions sometimes causing compression are substernal goiter, vertebral lesions, aortic dilatation, tuberculous glands and enlargement of the heart. Compression stenoses almost always affect the mid-portion of the esophagus. When viewed in the oblique position the encroachment of an aneurysm or aortic dilatation upon the retrocardiac space and its expansile pulsation make the diagnosis possible. Vertebral deformity, substernal goiter and cardiac enlargement show roentgenologic-

ally. The roentgenologic evidences of mediastinitis, mediastinal tumor anq tuberculous glands are less obvious, but the increased density without expansile pulsation is suggestive. Compression stenoses are likely to be associated with displacement of the esophagus, and this fact is important in differentiating them from lesions of the esophagus itself. Obstruction due to outside pressure, as by an aneurysm, is less marked than obstruction from an intrinsic lesion.

Some of the intrinsic causes of obstruction are cardiospasm, carcinoma, diverticulum, benign cicatricial strictures, foreign boiies, polypi and reflex spasm. To these might be added the rare cases of abscess (as from a foreign body), syphilis, tuberculosis and actinomycosis. A large diverticular sac when filled may exert sufficient pressure to obstruct the esophagus considerably.

It is noteworthy that the patient's dysphagia is often out of proportion to the roentgenologic signs of obstruction. With fluids or even with porridge there is often seen only slight delay or none at all. Barclay[6] sometimes gives such patients dry bread crumbs or crusts in order to excite spasm, and then follows with the barium mixture to show its seat.

Dilatation.—More or less dilatation is a common sequel of an obstruction. The most extreme dilatation is seen in cases of cardiospasm, in which the esophagus may attain a breadth of three fingers or more. Dilatation above carcinomatous stenosis is commonly less marked than above benign obstruction. A small, contracted, carcinomatous, syphilitic or high hour-glass stomach may cause dilatation of the lower esophagus by the backing up of the gastric contents.

The dilated esophagus consequent upon obstruction, especially that due to cardiospasm, often contains a quantity of fluid secretion through which the barium falls slowly, often in a winding manner, at first suggesting the irregular lumen of an esophageal carcinoma. Continued filling will indicate the condition. In such cases, evacuation with the stomach-tube and reexamination is advisable.

CARDIOSPASM

The chief roentgenologic characteristics of typical cardiospasm are the blunt or regularly conical obstruction at or near the cardia, and the secondary dilatation of the esophagus above it. The bolus may be seen moving up and down in the esophagus, more noticeably in the lower third. The smooth, symmetrical termination of the shadow, usually at the hiatus œsophageus, less frequently at the cardia, is rarely seen in any other condition. The dilatation is often extreme, involving almost the entire esophagus. It may thus attain a capacity of 500 c.c., or even more. In some cases, the dilated, sac-like esophagus may contain much fluid through which the opaque meal falls in blobs. Before the barium is given the dilated fluid-filled esophagus is occasionally visible on the screen at the side of the spine. The upper esophageal contour is fairly regular, but is sometimes indented here and there by sharp, moving contraction-waves or, occasionally, by a stationary spasmodic constriction. Because of the dilatation, peristalsis is not effective in its effort to propel the esophageal contents into the stomach. The patient depends upon increasing the intra-esophageal pressure by adding to its contents and by energetic contraction of the pharynx. Thus by drinking a glass of water after taking food, he is often able to overcome the obstruction at the cardia and drive the food into the stomach. In cases of long standing the esophagus may be more or less elongated and somewhat kinked, or S-shaped. Antiperistalsis has been noted and is a natural sequence of obstruction anywhere in the digestive tube.

Cardiospasm is to be differentiated chiefly from carcinoma and from benign organic stricture. Carcinoma of the lower esophagus rarely produces stenosis limited to the hiatus œsophageus, but nearly always extends above the diaphragmatic opening and, as a rule, the lower end of the barium shadow tails out irregularly. Post-traumatic strictures sometimes occur in the lower esophagus, but here again one may expect irregularity instead of the symmetrical cone of cardiospasm. However,

warning must be given that irregularity does not invariably signify organic obstruction, nor does smooth regularity invariably indicate cardiospasm. Exceptionally a cardiospasm may show a slightly devious tailing out, and exceptionally an organic stricture may not give rise to an irregular shadow.

Case 114,572, female, aged 27. During the past four years this patient has had intermittent attacks of discomfort behind the sternum while eating. The food seemed to lodge before entering the stomach. Upon drinking hot water the food seemed to pass suddenly

Fig. 9.—Cardiospasm. (*a*) Constriction. Note dilatation above.

into the stomach. Unless she remained quiet for a time after eating, the meal came up just as swallowed without nausea. During the past two years she seldom took a meal without this trouble. She drinks large quantities of liquid with her food. Cold water causes distress and is regurgitated immediately after swallowing. The patient is constantly losing weight.

Roentgenoscopy and the roentgenogram (Fig. 9) show marked obstruction at the cardia, where the esophageal lumen has a smooth, conical termination. Above the obstruction the esophagus is considerably dilated.

Dilatation with the hydrostatic bag effected a clinical cure.

Case 111,736, female, aged 30. Fourteen years ago she began to have occasional, sudden, sharp pain just behind the center of the sternum, intense for a few moments, with no food relation and relieved by belching. Two years ago she had a severe attack of vomiting and soon afterward began to have a choking sensation on swallowing solid foods. She frequently resorted to drinking water to force food down and became unable to eat a meal without taking considerable liquid. Later she began to vomit while at meals, and often was obliged to leave the table though hungry. There never was marked nausea. One year ago she began having her stomach washed out, and learned to use the tube herself, employing it once a week for the past eight months. She discovered on one occasion that the tube could not be passed into the stomach and called a physician who made a diagnosis of diverticulum. At present she vomits two or three times at each meal, and often cannot get sufficient food into her stomach to satisfy her hunger. No pain is experienced. Appetite good. Weight and strength slightly below normal.

Two roentgenograms are shown (Figs. 10 and 11). Figure 10, made at the first examination, shows obstruction at the cardia with an irregularity of its lower left border resembling the filling-defect of a neoplasm. In order to exclude food remnants as the cause of this appearance, the patient's esophagus was washed out with the aid of the tube and a second roentgenogram made (Fig. 11). In this the filling-defect has disappeared. Doubtless, therefore, it was due, as was suspected, to food bits. Both roentgenograms show the characteristic obstruction at the cardia with diffuse dilatation of the esophagus above.

Forcible dilatation was followed by clinical cure.

Case 105,770, male, aged 49. When a child the patient's esophagus was burned with hot mush, after which he spat up bloody mucus for a time. His chief complaint was difficulty in swallowing. He has had his present trouble since the age of 14 years; first noticed that in eating an apple, he had to drink water to force it down. This is true also with other solid foods. The patient states that he can feel the lower end of the esophagus loosen up and let food go through. Usually water alone will not go through and comes up sooner or later. He often awakens at night and has to rid himself of collected saliva. On a few occasions he has had to empty his esophagus of food after eating too heartily.

The roentgenogram (Fig. 12) shows marked obstruction at the cardia. The subdiaphragmatic portion of the esophagus is dilated,

Fig. 10.—Cardiospasm. Spasmodic constriction, *a*. Filling-defect due to food remnants, *b*.

Fig. 11.—Cardiospasm; same case shown in Fig. 10, after washing out esophagus. Constriction at *a*. Note absence of filling-defect.

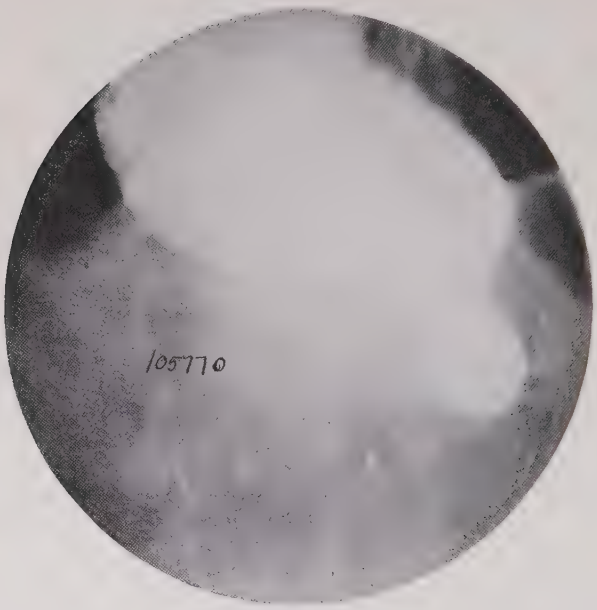


FIG. 12.—Cardiospasm. Hiatus esophagi, *a*. Constriction at cardia, *b*. Some dilatation of epicardia, *a* to *b*. Marked dilatation above *a*. Direct anterior view.

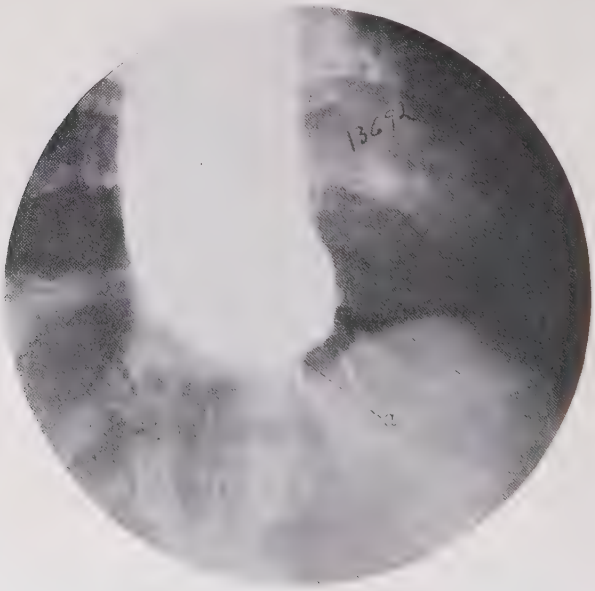


FIG. 13.—Cardiospasm. Spasmodic constriction at *a*.

FIG. 14.

FIG. 15.

FIG. 16.

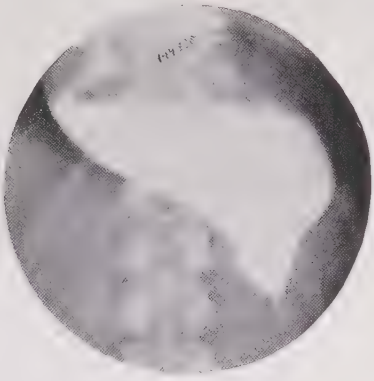


FIG. 17.

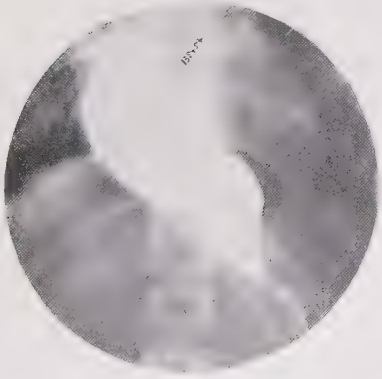


FIG. 18.

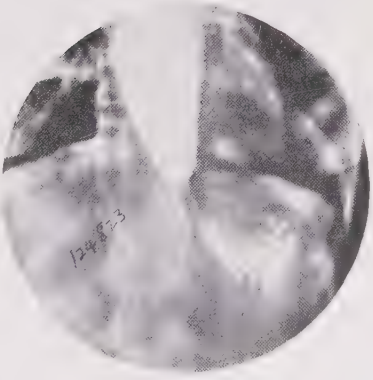


FIG. 19.

FIGS. 14, 15, 16, 17, 18 and 19.—Roentgenograms illustrating cardiospasm.

but above the hiatus the esophageal dilatation is extreme and extends to the upper border of the sternum, the esophagus having a diameter of approximately 9 cm. The cardiospasm was relieved by forcible dilatation with the hydrostatic bag. It is of interest to note, as a possible etiologic factor, that for some years the patient had also had symptoms suggestive of duodenal ulcer. About two years after the esophageal stretching, the presence of a duodenal ulcer was confirmed by roentgen examination, and verified at operation.

Case 136,926, male, aged 37. In a letter this patient related a typical history of cardiospasm, as follows: "I have had all manner of treatment but it seems to do no good. Twelve years ago I had a bougie passed down my throat and into my stomach once a day for thirty days. Then I took all kinds of vibration and electrical treatments without benefit. Whenever I eat anything I have to drink a lot of water to push it through into the stomach. Sometimes it will not go through but comes back up again. Otherwise, I am apparently well."

In the roentgenogram (Fig. 13), is seen the characteristic obstruction with dilatation of the esophagus above. The spasm was so pronounced in this patient that half the motor meal was retained after six hours. Following dilatation of the constriction by the hydrostatic bag, recovery was complete.

CARCINOMA

The situation in order of frequency of esophageal carcinomas has been variously stated. On the whole, it appears that they are exceedingly rare from the introitus to the tracheal bifurcation, are more common below the tracheal bifurcation and most comomn in the cardiac portion.

The facility with which esophageal cancer can be shown by the x-ray depends largely upon the degree of obstruction. Those which are decidedly obstructive are characterized, as a rule, by tortuous irregularity of the stenosed lumen. Above the stenosis there may be some dilatation, but this is usually less marked than in cases of benign obstruction. Antiperistalsis has been noted above the point of obstruction. In some cases of cancer of the esophagus not involving the cardiac opening, the latter remains gaping, without producing the usual physiologic retardation of the material swallowed.

The detection of early, nonobstructive cancer is more difficult. The esophageal contour, outlined by the barium-acacia mixture, will show filling-defects proportionate to the growth, but these must be carefully differentiated from the numerous normal irregularities. In a few instances, observers have noted reflex esophageal spasm accompanying early cancers.

Obstructive carcinomas must be differentiated from benign organic and spasmodic strictures, and from pressure stenoses. In any of these there may be irregularity of the esophageal

FIG. 20.—Carcinoma of the esophagus. Filling-defect and obstruction *a*.

lumen, though less constantly than in carcinoma. Rarely, a diverticulum may somewhat resemble the roentgenologic aspects of esophageal cancer, and diverticula may result from obstructive cancer. In many cases of carcinoma the only roentgen sign found will be some degree of obstruction and a complete diagnosis can be made only by taking the clinical features into account.

Case 113,484, male, aged 64. For three months he has had a persistent dysphagia, increasing in severity. At present he can swallow

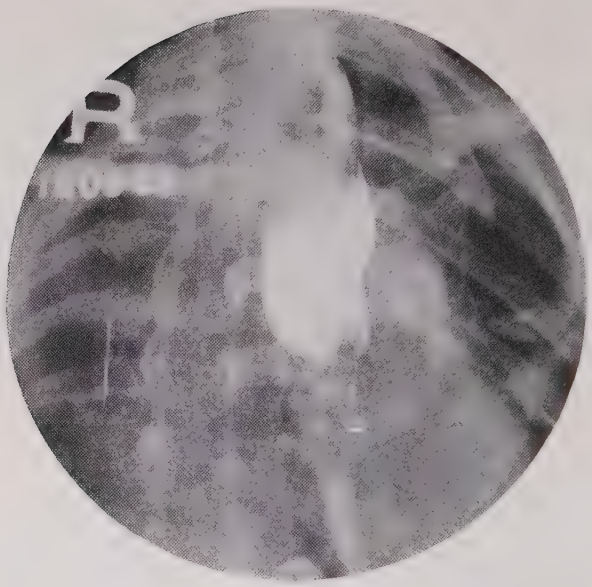


FIG. 21.—Carcinoma of the esophagus. Stenosis with irregular filling-defect, *a*.

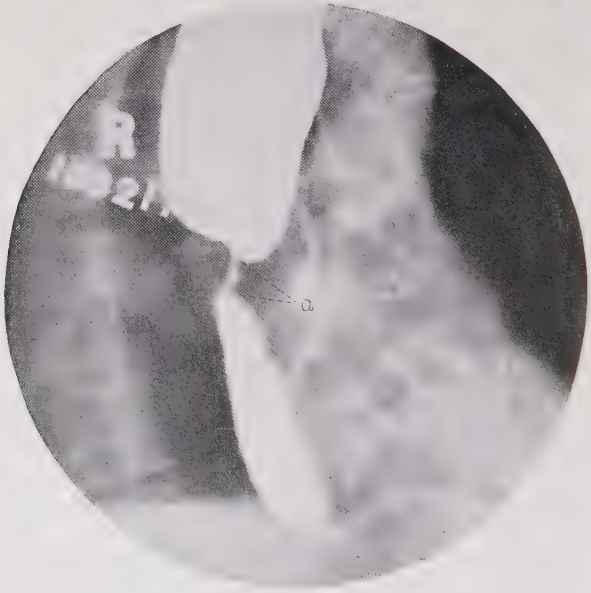


FIG. 22.—Carcinoma of the esophagus. Irregular obstruction at *a*.

no solid food and takes semi-solids and liquids with difficulty. He regurgitates stringy mucus. Attempts at swallowing cause some pain under sternum radiating to back. He has lost 45 pounds in nine months, mostly in the last three months, and has grown weaker.

The roentgenogram (Fig. 20) shows obstruction and irregular filling-defects in the mid-portion of the esophagus. The denser shad-

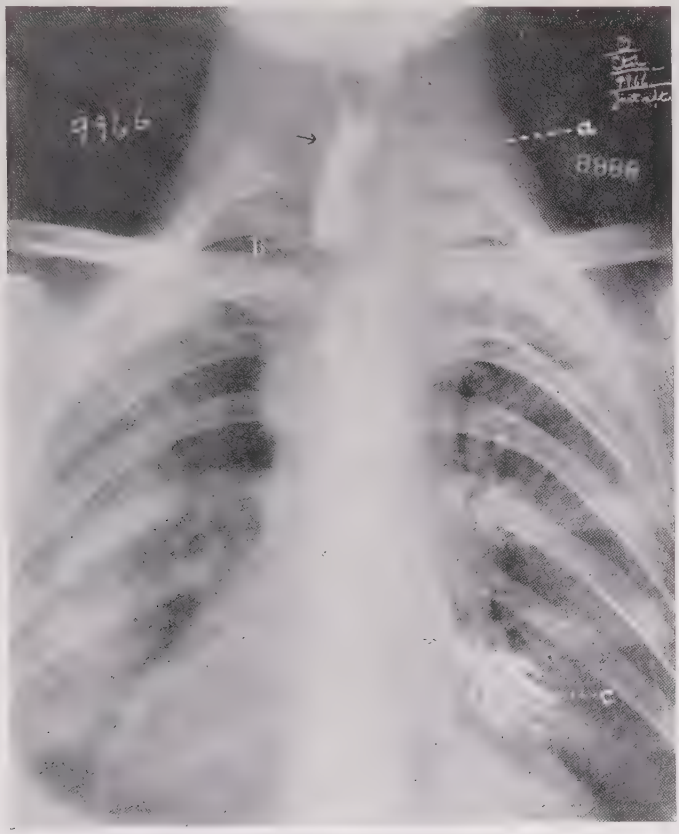


Fig. 23.—Carcinoma of the esophagus. Infiltration and obstruction, *a*. Pulsion sac, *b*. Bismuth in left bronchial tree inhaled while swallowing, *c*.

ows are produced by a retention of the six-hour meal, while the thinner shadow above is the barium gruel taken at the time of examination. Esophagoscopy showed a cauliflower carcinomatous growth in the middle third of the esophagus.

Case 120,943, female, aged 34. Patient states that when a child three years old she swallowed some acid used by tinners in soldering. She does not remember any subsequent trouble in swallowing until

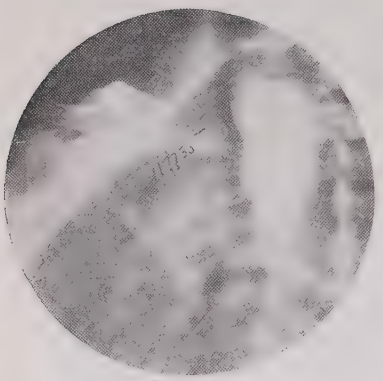


FIG. 24.

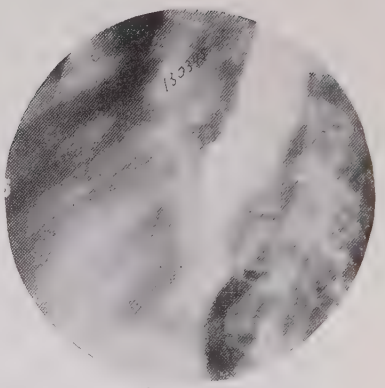


FIG. 25.

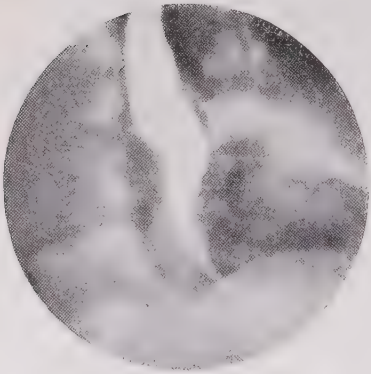


FIG. 26.

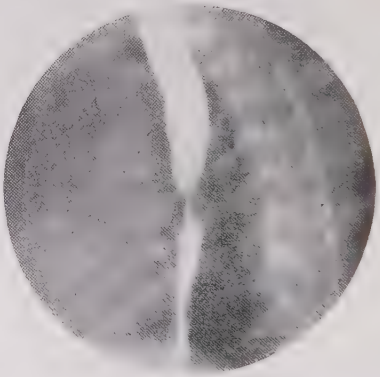


FIG 27.

FIG. 28.

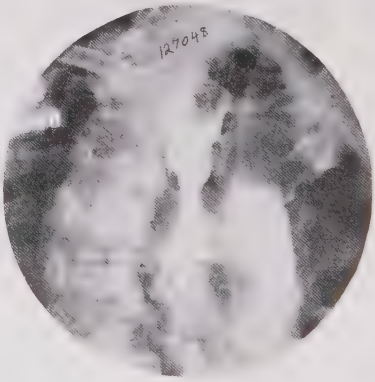


FIG. 29.

FIGS. 24, 25, 26, 27, 28 and 29. Illustrative cases of cancer of the esophagus.

one year ago when attempts to swallow large bits of meat caused choking. Eight months ago the dysphagia began to be constant and mouthfuls of food were regurgitated. She is now able to take liquids only. She has lost about 30 pounds during the last eight months.

The roentgenogram (Fig. 21) indicates irregular obstruction in the middle third of the esophagus, without marked dilatation above.

Esophagoscopic examination: Growth in the middle third of esophagus, thought to be carcinoma.

Case 133,217, male, aged 67. Six months ago began to hiccough at meal time. Nothing further was noticed until three months ago when he began to have dysphagia, the pain being referred to the upper sternal region. Later, attacks of vomiting commenced, and these have continued, much mucus and unsoured food being ejected with the vomit. Weight loss, 20 to 30 pounds.

Roentgenogram (Fig. 22). Obstruction at the lower third is well marked. The irregularity of contour was clearly seen on the screen.

Case 44,345, female, aged 46. Ten months ago she had difficulty in swallowing which diminished for a month, then increased until for the past three months she has been unable to take solid food. The food seems to stick at about the upper border of the sternum, and is quickly regurgitated. Weight loss, 25 to 30 pounds.

The roentgenogram (Fig. 23) shows: (*a*) Irregular obstruction high in the esophagus, (*b*) pulsion sac, (*c*) bismuth in right bronchial tree inhaled during attempts to swallow.

DIVERTICULUM

The classification of diverticula into "pulsion" or "pressure" sacs and "traction" sacs is generally accepted. The pulsion sacs, which are by far the most numerous, are produced by internal pressure and occur nearly always at the pharyngo-esophageal juncture (the introitus) where there is a tendency to deficient musculature, and where anomalies in closure of the lower branchial clefts may play a part. Traction sacs result usually, it is claimed, from gland infection about the left bronchus; they are rare, have few symptoms, and are generally found at necropsy only. Pulsion diverticula may be situated laterally or posteriorly. In size, diverticula vary from 5 mm. to 8 cm. or more. When filled with the opaque mixture, a pulsion diverticulum commonly shows on the screen or plate

as a symmetric sac with a smooth, rounded base. In exceptional instances, the sac may appear to be somewhat irregularly shaped; retained food bits may give rise to such irregularity. Its fluid contents have a level upper surface. Its position with reference to the esophagus can be determined usually by the course of the barium through the latter, but the introduction of an opaque bougie into the esophageal lumen will show the relations better on the screen or in the roentgenogram.

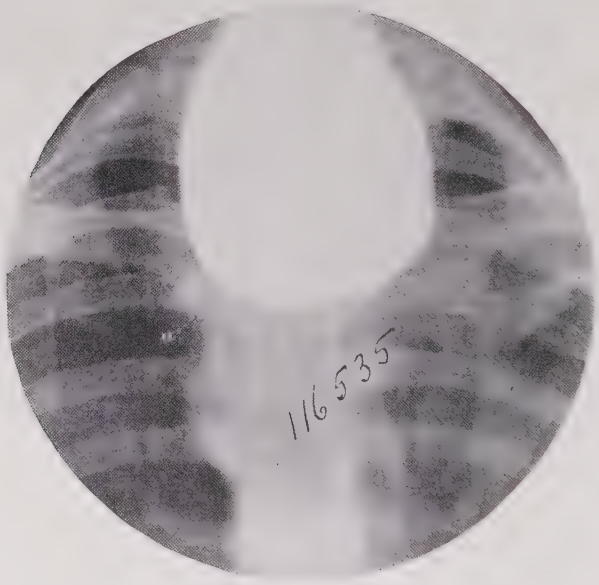


Fig. 30.—Diverticulum of the esophagus, *a*

The sac or its major portion lies below its opening into the esophagus, at which point the overflow drainage into the esophagus can sometimes be observed.

Dilatation above a high-seated carcinoma or benign stricture may somewhat resemble a diverticulum, and this resemblance is heightened if the dilatation has become pendant so that it no longer drains from its lowest point. In carcinoma the strictured lumen below the dilatation is commonly irregular. It is noteworthy that diverticula rarely become carcinomatous.

Case 116,535, male, aged 55. Seven years ago he began to have occasional attacks of choking with food, and at times when lying down felt as if an object were rising in his throat with a bubbling sound then falling back again. The choking increased in severity until two years ago. Since then it has diminished, but the amount of food he is able to take has also diminished. When the pocket fills, its contents are often regurgitated through his mouth and nose two to five times during a meal. At night food in the sac causes distress. During the past year he has formed the habit of taking a swallow of water and then expressing the contents of the sac by massage with the finger, which enables him to sleep with comfort. He is obliged to chew his food well and swallow slowly. To him it seems that no food goes into his

FIG. 31.—Photograph of specimen.

stomach until the pocket is filled, and then there is a choking sensation. There has been an increasing change in the tone of his voice since the trouble set in.

During the screen examination, the pocket shown in the roentgenogram (Fig. 30) was seen to fill with the barium gruel after which the gruel trickled down the esophagus, showing that the sac was a diverticulum. Note the characteristic situation and contour.

Finding at operation: Diverticulum, 5 cm. in diameter, coming off the left side near cricoid. Excision of sac (Fig. 31).

Case 2492, male, aged 55. For eleven years the patient at times has had regurgitation of food immediately after eating. The trouble has grown worse during the past two years, and although he has a good appetite he cannot eat with satisfaction. Food regurgitates through the nose occasionally. He has kept to his bed for the past ninety

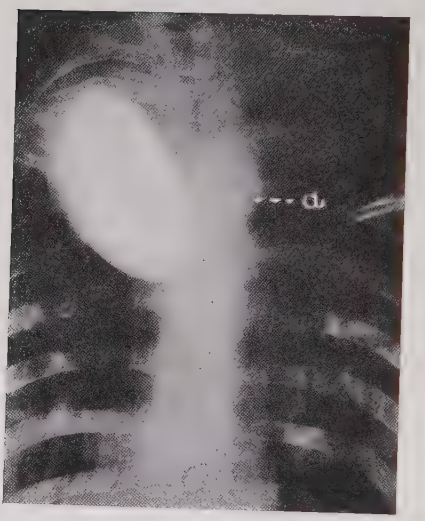


FIG. 32.—Diverticulum of the esophagus, *a*.

FIG. 33.—Oblique view of small esophageal diverticulum, *a*.

days, has lost strength and his normal weight of 135 pounds has declined to 90 pounds.

The roentgenogram (Fig. 32) shows a very large, kidney-shaped, diverticular sac coming off to the right and extending upward, because of less resistance in that direction. It gives the impression that the esophageal opening is lower than the highest portion of the sac, but this is due to the fact that the neck of the sac and the esophageal opening, which is higher up, are not visualized.

Operative findings: Diverticulum, right side of esophagus, lying under sternum.

Case 99,346, male, aged 66. Dysphagia with regurgitation began six years ago. This has continued, but by eating slowly he gets along fairly well. To him the seat of obstruction seems to be just below the cricoid. Liquids give more difficulty than solids.

Roentgenogram (Fig. 33), oblique view. Small diverticular sac coming off opposite the cricoid.

DEEP-SEATED DIVERTICULA

The diagnosis of deep-seated diverticula of the esophagus has passed through the three chronologic stages common to the recognition of pathologic anatomy of the intestinal tract. Although in Lotheisen's[7] article we find de Guise quoted as having found, in 1833, a diverticulum which "because of its form, its position, its direction, and distention compromised the upper opening of the stomach and prevented the free passage of food," prior to 1892 (Bordoni)[8] necropsy alone seems definitely to have demonstrated the cause of difficulty in swallowing, regurgitation and vomiting of food, painful pressure and coughing which are associated with the condition. During the next few years cases of deep-seated diverticula were fairly conclusively diagnosed *intra vitam* by differentiation of these symptoms and by clinical tests by Mintz,[9] Reichmann,[10] and Kelling.[11] Reitzenstein[12] in 1898 was evidently the first author to confirm clinical evidence of a deep-seated diverticulum by an x-ray picture. Since then roentgenology has been quite generally employed to determine the presence of all the diverticula of the lower portion of the esophagus.

Brosch[13] in his tabulated summary of deep-seated esophageal diverticula reported in the literature before 1900, credits Oekonomides[14] (1882) with the first case found at necropsy; Tetens,[15] Przewoski,[16] Starck,[17] Hausmann,[18] Brosch and Olivetti[19] have described similar specimens. Oekonomides' first case was that of an eighty-three-year-old woman; eight and a half centimeters above the cardia was a thin-walled, anterior esophageal diverticulum five and a half centimeters deep, and lined with normal mucous membrane, widening out from an orifice three and a half by one and one tenth centimeters in the regionally dilated esophagus; this sac was classed as a pulsion diverticulum. The second diverticulum which Oekonomides found three and a half centimeters above the cardia of a sixty-six-year-old woman, he thought might be of "mixed origin;" Brosch designates it as a "traction-pulsion" type because its tent-shaped end was grown fast to the right lung and to a calcareous body which was probably a lymph gland. The "mixed" characteristics of this case were also observed in Tetens' case of diverticulum found three centimeters above the cardia at necropsy of a man aged seventy-eight. The shape of the sac with its few stretched muscular fibers and the condition of the nearby lymph glands led Brosch to assume their previous connection and to class the diverticulum with the "traction-pulsion" type.

Olivetti places under the same head the diverticulum of the right anterior esophageal wall, three centimeters above the cardia, found in Starck's postmortem case, and the diverticulum of the esophageal specimen of the anterior wall taken at necropsy from a sixty-seven-year-old woman, which Hausmann describes. The pouch in this case was three centimeters long, one and a half centimeters wide, and four centimeters above the cardia. Olivetti himself reports a case in which the structure of the epiphrenic diverticulum, a sac the size of a hen's egg lying close to the diaphragm and one centimeter above the cardia of a man sixty-eight years old, led him to believe that it was a congenital defect. The esophageal specimen which Brosch describes was taken from a man aged sixty-seven. A pulsion

diverticulum three centimeters above the cardia formed a pocket between the slit-like separation of the muscle fibers. The hazel-nut sized diverticula, which Przewoski is reported to have found in the middle portion of the lower third of the esophagus at seven different necropsies, also showed no signs of synechia on their outer surfaces. As the type of diverticulum can generally be determined only after death, these cases are primarily interesting from the standpoint of their etiology and rarity; as no clinical symptoms are given in connection with them they form but the anatomic introduction to the clinical aspect of the pathology and diagnosis of deep-seated diverticula.

The second stage in the diagnosis of deep-seated diverticula of the esophagus was introduced by the study of differential symptoms of dilatation of the esophagus, cardiospasm, and diverticulum, and by ingenious, if not infallible tests to prove the presence of a diverticulum. In the literature this period was ushered in by Bordoni's article (1892). Within the next decade the first crude sketches of x-ray plates marked the advent of the contemporary deciding factor in diagnosis. As the indication for x-ray examination must rest upon the clinical evidence of each case, study of that evidence should be made most valuable, it would seem, by the consideration of cases diagnosed without and with the aid of the x-ray. The literature has been reviewed from this standpoint.

From the collation of 14 cases of deep-seated diverticula reported during the twenty-seven years since Bordoni's article appeared, these statistics have been compiled. Only two of the 14 patients were women; Nékrassoff-Motoviloff[20] suggests that "immunity which the woman enjoys may be explained by the tardy ossification of the female larynx and by her smaller dimensions." The age of the patients ranges from thirty-five to sixty-four; their average age is forty-seven. The serious symptoms of the traction diverticulum of Weiss's[21] patient began a few months after injury from a shrapnel ball which grazed the sixth rib, and which must have passed through the

diaphragm, while Jung's patient first noticed difficulty in swallowing twenty-four years before consulting him. The gradual increase in severity of the symptoms in most of these cases no doubt indicates pulsion diverticula, especially as "rather delicate bony structure, slight panniculus, and insufficient musculature" are noted in the description of the general health of many of the patients. Congenital defects probably play the largest causative rôle in deep-seated diverticula which may also be the result of intrathoracic, mediastinal, or esophageal trauma and of pulsion independently or in association. The bullet-shaped pouch probably represents the pulsion diverticulum while the traction or traction-pulsion diverticulum is more apt to be tent-shaped. The right anterior esophageal wall is mentioned most frequently as the location of the diverticula which are found from thirty-five centimeters (Nékrassoff-Motoviloff) to forty-seven or forty-eight centimeters (Jung,[22] Reitzenstein) from the incisors and which vary in size from that of the "end of the thumb" (Lotheisen's case reported by Kaufmann and Kienböck[23]) to those which have a capacity of three hundred cubic centimeters or even five hundred cubic centimeters as in Reichmann's case. (This case has, however, been questioned; Landauer,[24] for instance, thinks that it may be "a spindle-shaped dilatation of the esophagus.") As the length of each person's esophagus varies with his build, the distance of the diverticulum from the cardia and its position in relation to the diaphragm cannot be reckoned by the depth at which the obstruction is met by the esophageal or stomach probe. Although the diverticulum in Jung's patient was forty-seven centimeters from the incisors, the roentgenogram demonstrated that it was above the diaphragm and about two centimeters above the cardia. Conversely, the probe met an obstruction thirty-eight centimeters from the incisors of the patient whose case Nékrassoff-Motoviloff describes; at operation the diverticulum was found below the diaphragm, thirty-five centimeters from the incisors, although all the eleven supraphrenic diverticula described in the literature reviewed were forty or more centi-

meters from the incisors. The second subphrenic diverticulum was demonstrated by the roentgenogram of Weiss's patient.

The clinical symptoms exhibited in all the cases of deep-seated esophageal diverticula have a general likeness. The history of the trouble begins either with difficulty in swallowing and in breathing, and a feeling of pressure or of pain in the chest or in the pit of the stomach with and after meals. The sticking fast of food in the esophagus, regurgitation or vomiting of food before it reaches the stomach or soon afterward, may be associated with the difficulty in swallowing from the onset of the trouble which may recur at first only spasmodically, later to be repeated invariably with or after eating. Usually the pain and retching is more severe when solid food is eaten; one of Zweig's[25] patients could take nothing but fluids and semi-fluids, which was the type of nourishment Dr. Lotheisen's patient lived on during the last two years of his life. Sometimes a drink will help to force food down the esophagus into the stomach; usually vomiting is a relief. One patient (Nékrassoff-Motoviloff) could by a peculiar contraction of the esophagus empty the sac which he felt filling during his meals and which when full caused pain and prevented the passage of food into the stomach. The vomitus of Mintz's patient consisted always of food taken the day before, while remnants of meals taken as much as forty hours previously were found in the food forced up by retching of Landauer's patient; such a circumstance seems definitely to point to diverticulum. Regurgitation of food from the esophagus may be painless, but the vomiting caused by diverticula seems always to follow retching and exertion.

As the pain while eating and the difficulty in passing food into the stomach may characterize cardiospasm and dilatation of the esophagus, prior to the use of the x-ray, the examiner who suspected the presence of a diverticulum in his patient was forced to invent various methods, some of which are still in use, to prove his assumption. The probe which meets with an obstruction from thirty-eight to forty-eight centimeters from the incisors may also find a stenosed esophagus equally impervious

and a supracardially dilated esophagus no less misleading. Jung makes the statement, however, that after the esophagus is emptied, if the abnormality is a diverticulum, a tube should pass through the cardia without great difficulty. Diagnosis in one case (Nékrassoff-Motoviloff) depended upon the esophagoscope which disclosed the spur-like fold of mucosa projecting into the lumen of the esophagus. Some of the earlier authors mention hearing only the first of the deglutition sounds. Mintz who heard both sounds equally well says, "the presence of the second sound does not indicate esophageal or cardiac stenosis;" Landauer heard the second sound only now and then. Although Kelling seems to have depended upon deglutition murmurs in making his diagnosis, Kaufmann and Kienböck, and Weiss do not even mention them; the illumination test has also been abandoned. These last two tests, always doubtful in their variability, have become of less importance since the use of the x-ray. Landauer, Zweig, Jung, and Mintz all stressed the fact that the contents aspirated from the esophagus after a meal reacted strongly to lactic acid tests and negatively to hydrochloric acid tests, while food removed from the stomach gave exactly opposite results.

Some tests and examinations which preceded roentgenology are still necessary to the differential diagnosis of diverticula of the esophagus; but in some cases the roentgen examination can independently and certainly establish the presence of an epiphrenic diverticulum before the more distressing methods of examination are used. As Nékrassoff-Motoviloff is the only one of the authors to report negative x-ray findings, it might add to our knowledge of the radiology of diverticula of the esophagus if we knew whether the sac had been emptied of its contents before the patient was given the opaque meal, for it seems probable that the barium might pass by the sac if it were filled with débris. If the x-ray examination is negative in a suspected case of deep-seated diverticulum, the esophagus should be aspirated and reëxamined. Reitzenstein, Landauer, Zweig, Jung, and Kaufmann and Kienböck made their x-ray examinations an aid, not the deciding factor in their evidence

for cases of deep-seated diverticula; only Weiss of the authors mentioned seems to have relied largely on the roentgen method of diagnosis. Instead of giving an opaque meal, Landauer evidently roentgenographed his patient after he had introduced the esophagus and stomach probes, and considered their position. Jung's examination by means of the x-ray "did not give very satisfactory results as far as details were concerned, although the shadow bulging to the right of the shadow corresponding to the vertebral column showed the location of the diverticulum." The sac in Zweig's patient was filled with bismuth and x-rayed by Levy-Dorn; a "less pronounced shadow about the size of a dollar near the intensive shadow of the probe must be the barium filled sac." Kaufmann and Kienböck in making their diagnosis place greater faith in the roentgen pictures which they describe and sketch for their article. Weiss contributes copies of plates to illustrate his case of subphrenic diverticulum which still contained barium forty-one hours after the meal was taken. The use of the probe is undoubtedly dangerous, and especially if a thread is not used with it as a guide. The diaphane and the esophagoscope may be similarly injurious and unnecessary. Rumpel's test with the Zweig and Jung modifications are often needless and always unpleasant. The patient who complains to the clinician of pain and pressure in the chest, obstruction of the esophagus, regurgitation and vomiting, especially of food taken some time before, should be referred for a routine x-ray examination as this may demonstrate the presence of a deep-seated diverticulum as clearly as it does the more frequent cervical diverticulum. A case to add to the list of diverticula of the lower third of the esophagus was observed in the Mayo Clinic.

Case 197,786,* a man aged 42 came for examination July, 1917. He gave a history of having had stomach trouble for twenty years with a feeling of nausea and fullness periodically, but without regurgitation of food or sense of obstruction until five years before when he had

* Dr. H. P. Hill of San Francisco referred the patient to us and kindly furnished the previous history of the case.

vomited some dark blood, and then had more definite trouble with regurgitation of acid food and mucus.

In June, 1912 an examination was made by Dr. Hill, at which time there was a mitral systolic murmur and the heart was two centimeters outside the left nipple line. The pulse rate was 58; the systolic pressure was 120. There was liver dullness two centimeters below the costal margin, and slight tenderness was noted in the epigastrium. The roentgen plates showed a hypertonic stomach high and to the right.

FIG. 34.—(Case 197,786). Diverticulum of the lower third of the esophagus; diverticular sac at *D*.

The patient's use of alcoholics, his enlarged liver, and the vomiting of blood without pain were suggestive of cirrhosis of the liver, but the definite food stasis, periodicity, time of distress and nausea, together with the x-ray findings were more strongly suggestive of duodenal ulcer and of the possibility of cholecystitis.

In December, 1913, Dr. Hill and Dr. Moffitt in consultation, examined the patient and a diagnosis of duodenal ulcer was made. Medical treatment was advised. The roentgen examination of the

esophagus was negative. About this time the patient went to Los Angeles to take a milk cure and improved slightly under the treatment. Later he had typical nocturnal epileptic attacks, but was able to attend to business. Food produced pain and a burning sensation when it passed a certain point under the sternum.

Early in 1917 Dr. Ruggles of San Francisco made a roentgen examination, and a diverticulum, containing an air bubble at the top was found just above the diaphragm to the right of and in front of the esophagus. There was no dilatation of the esophagus. It was noted that with the patient in the knee-chest position the diverticulum could be partially emptied.

A roentgen examination made at the Mayo Clinic July 14, 1917, demonstrated a diverticulum of the lower third of the esophagus (Fig. 34). The patient could partially empty the sac by regurgitation just as patients with cardiospasm sometimes do. The stomach and duodenum were negative. The diagnosis was corroborated clinically. The patient was treated by hydrostatic dilatation of the cardia.

CICATRICIAL STRICTURES

Cicatricial stenoses may be the result of a healed ulcer, either simple, tuberculous or syphilitic, or of a trauma, such as results from drinking caustic liquids. In traumatic cases the stricture may not cause dysphagia until many years after the receipt of the injury. Such strictures may occur at any point in the esophagus. Often the esophageal lumen above the stenosis is slightly dilated and shows a rounded, smooth, symmetric termination, from which a thin stream of barium trickles through the stenosis. Thus, if located high up, the condition may be mistaken for a diverticulum, but in the latter instance the drainage is from the upper part of the sac and not from the bottom as in stenosis.

Other than the finding of obstruction with dilatation above it, both of which of course, vary in degree, the roentgenologic appearance of benign organic stenoses is not especially characteristic, and differentiation from other obstructive conditions will depend upon the history and data elicited by other means.

Case 118,020, female, aged 50. When five years old this patient swallowed lye. During childhood she had some difficulty in swallow-

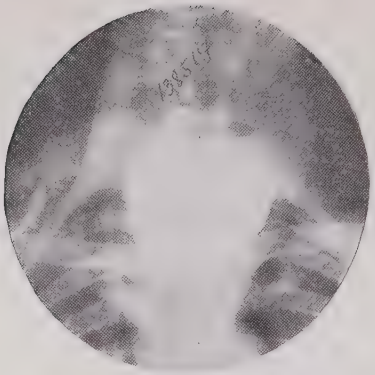


FIG. 35.

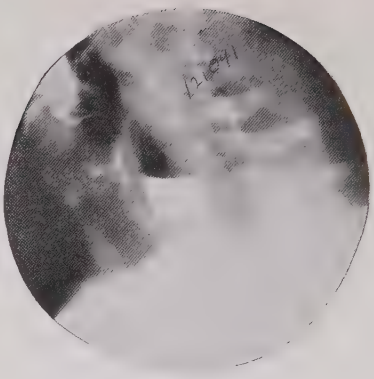


FIG. 36.

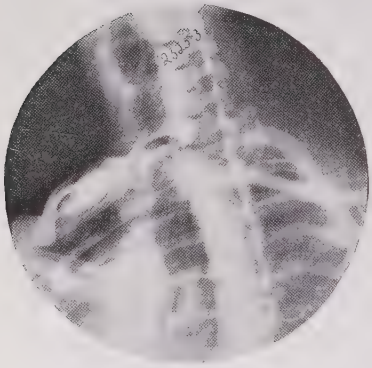
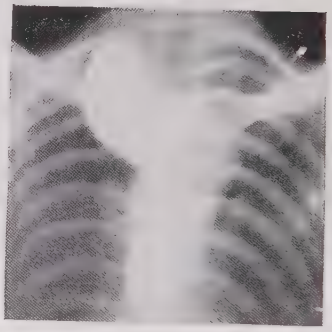


FIG. 37.



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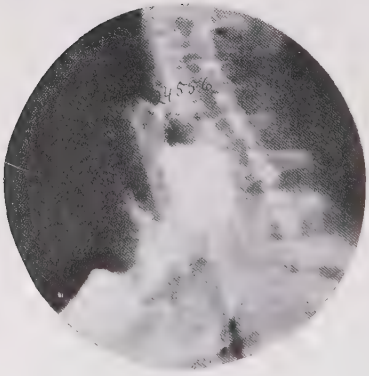

FIG. 39.

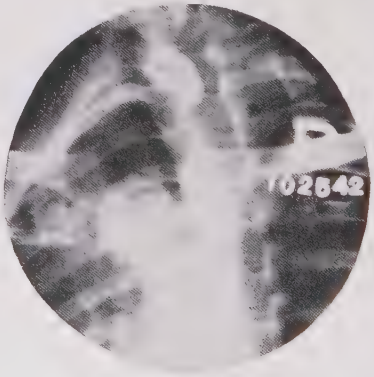

FIG. 40.

FIGS. 35, 36, 37, 38, 39 and 40.—Illustrative cases of diverticulum of the esophagus.

FIG. 41.

FIG. 42.

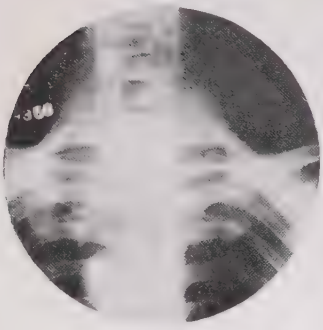

FIG. 43.

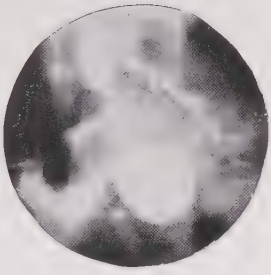

FIG. 44.

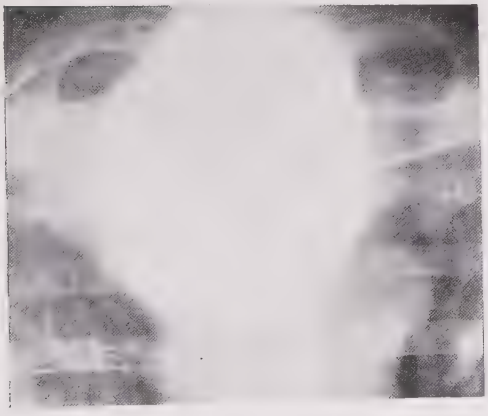

FIG. 45.

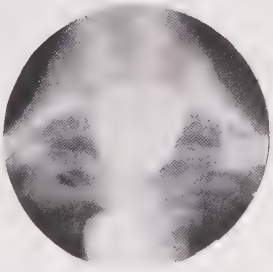

FIG. 46.

FIGS. 41, 42, 43, 44, 45 and 46.—Illustrative cases of diverticulum of the esophagus.

ing, but gradually grew better, although she has always had to masticate food well or it would stick. Seven years ago she thought something lodged in the stricture, as she was obliged to take liquids only for several weeks. A similar attack came on rather suddenly about three weeks ago.

The roentgenogram (Fig. 47) shows marked constriction of the esophagus opposite the aortic arch, with barium trickling through the

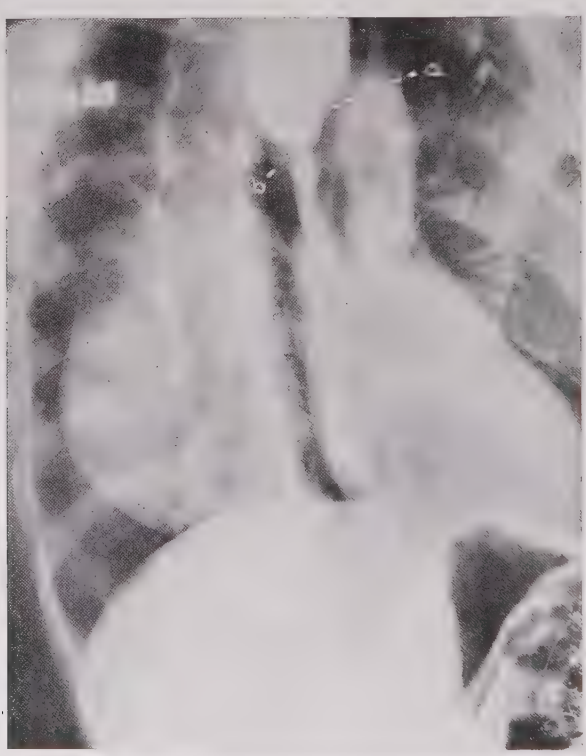

Fig. 47.— Indentation due to aortic arch, *a*. Benign stricture of the esophagus with barium trickling through, *b*.

stricture. The indentation caused by the arch can be noted. The esophagus is somewhat dilated above the stenosis.

Case 117,800, male, aged 2½ years. Eight months ago he drank a strong solution of lye. Since then he has been unable to retain anything but milk. Solid food is vomited in from a few seconds to one hour after eating.

The roentgenogram (Fig. 48) shows obstruction in the middle third of the esophagus, with dilatation above.

Case 122,779, female, aged 38. Two weeks after gastro-enterostomy for a duodenal ulcer the patient developed marked dysphagia. A stricture was found by the esophagoscope. Later, a gastrostomy was performed. At this time no evidence of malignancy was found, but the cause of the stricture was never determined.

Roentgenogram (Fig. 49), shows stricture in lower third of esophagus, smoothly regular, and evidently not malignant.

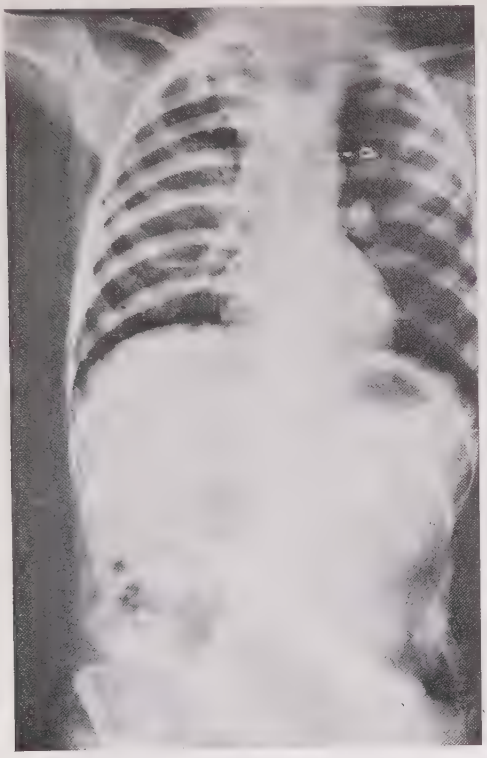

FIG. 48.—Benign obstruction of esophagus. Stricture at *a*.

SPASM

Aside from spasm at the cardia, spasm may occur also anywhere along the course of the esophagus, with more or less consequent obstruction. Such spasm has been seen as a reflex from early carcinoma. By analogy one would expect spasm of the esophagus as an occasional reflex from gastric irritations,

just as gastric spasm is sometimes seen in duodenal irritation. Barclay[26] holds that a small esophageal abrasion or ulcer may set up a spasm of such severity and persistence that complete obstruction may result, and he mentions a case of this character in his experience. He believes that simple or peptic ulceration of the esophagus is of more frequent occurrence than is commonly taught. Transitory reflex spasms are not likely to be demonstrated, unless the examiner is unusually fortunate.

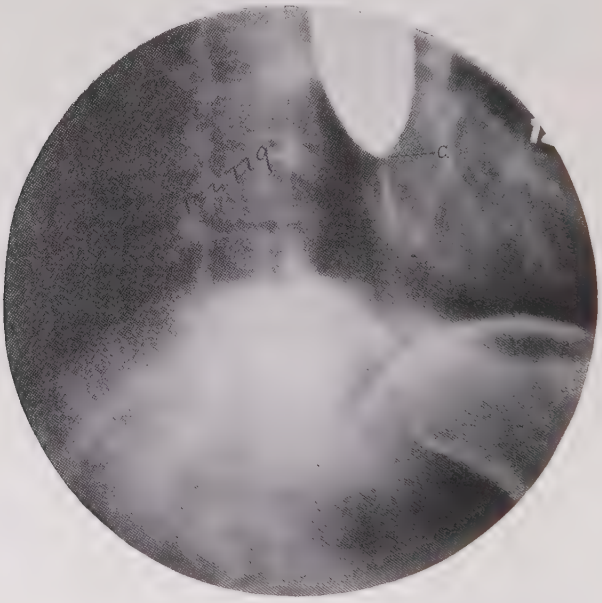

Fig. 49.—Benign obstruction; barium trickling through stricture at *a*.

FOREIGN BODIES

The foreign bodies which are now and then found lodged in the esophagus include coins, dental plates, bones, pins, buttons, rings and the innumerable objects which most children and some adults put into their mouths. The point of lodgment may be anywhere in the esophageal course, though more often it is at the anatomic narrowings, such as those at the aortic arch and the introitus. Arrest of a foreign body may be due to an organic stenosis. Demonstration of a foreign body by the

roentgen-rays depends upon its size and density. Small bones, bone buttons and cartilage are not easy to detect even on the plate. Roentgenoscopic localization of non-opaque bodies may sometimes be aided by giving the barium mixture and discovering the point where the stream is obstructed or turned aside. An illustration of this is seen in Fig. 50.

Case 101,410, male, aged 2½ years. Eleven days previously he had swallowed a coin 2.5 cm. in diameter which caused vomiting and some bleeding from the nose. Since then he has been unable to swallow anything except liquids.

The roentgenogram (Fig. 51) shows foreign body (coin) high in the esophagus. This was definitely determined by screening the patient in the oblique position.

MISCELLANEOUS ESOPHAGEAL LESIONS

Although they have no diagnostic roentgenologic signs, there are possible conditions, other than those mentioned above,

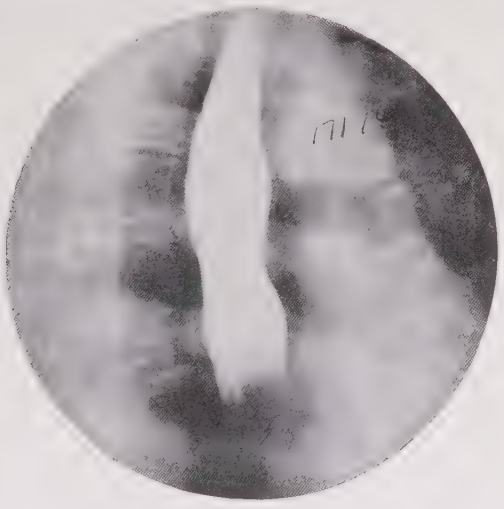

Fig. 50.—Complete obstruction in lower third of esophagus by a portion of beefsteak. Note peristalsis above the obstruction.

which the roentgenographer must bear in mind in drawing his conclusions. Patients have been seen who had paralysis of the esophagus and were unable to swallow solids, but could take liquids readily. Fistulous communications between the esophagus and the trachea or bronchus exist occasionally,

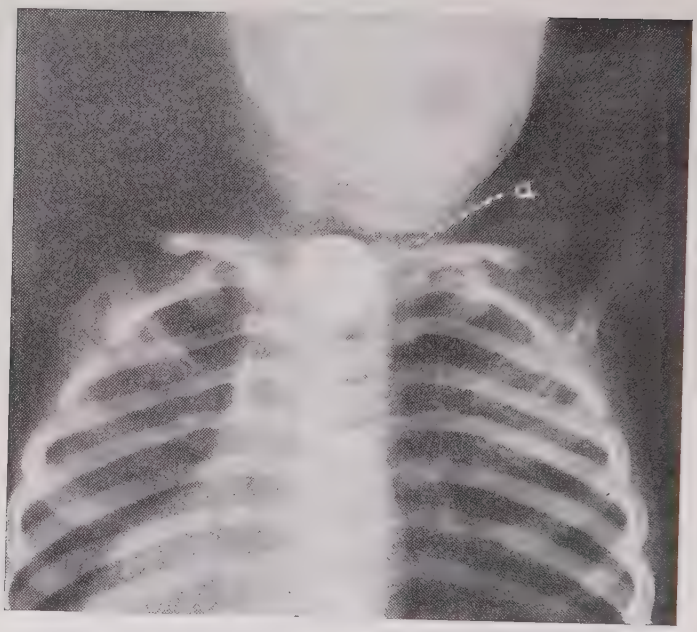

FIG. 51.—Coin in the esophagus, *a*.

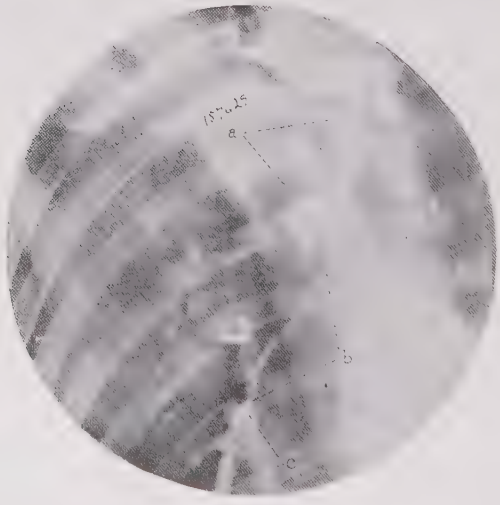

FIG. 52.—The irregular stenosis due to the cancer is seen at *a*. Below this is seen the fistulous tract through which barium has passed into the main trunk of the left bronchus, *b*, and its lower branches *c*. Verification by autopsy.

occurring as a result of wall-destruction by carcinoma (Fig. 52), tuberculosis, abscess or foreign body. In such cases, the fistula may be traced by the course of the opaque mixture, but this method of examination, because of its obvious possibilities for evil, is hardly to be recommended when the history is indicative of the condition. Esophageal varices may give symptoms of obstruction, but no cases with roentgenologic signs have been reported. I have seen one case of bulbar palsy in which the barium lagged both at the introitus and at the cardia. Although infrequently met with, esophageal polyps sometimes exist. Stewart[27] describes them as situated high in the esophagus, usually pedunculated and sometimes of considerable size. Roentgenologically they simply give signs of obstruction.

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CHAPTER V

THE STOMACH

TECHNIC

The examination of the stomach comprises four steps, as follows: (1) preparation of the patient; (2) administration of a six-hour meal; (3) roentgenoscopic examination; and (4) roentgenography.

Preparation.—On the evening previous to the day of examination, the patient is permitted to eat his evening meal as usual, or the special meal prescribed by the gastroenterologist if the gastric contents are also to be examined. He is instructed to omit breakfast the next morning, and either go first to the gastroenterologist for examination or come directly to the roentgen laboratory.

The Six-hour Meal.—At the roentgen laboratory the patient is given 60 gm. of well-cooked wheat breakfast food in which has been stirred 60 gm. of barium sulphate. To this he may add milk (not cream), and a little sugar according to his taste. He is directed to abstain from other food or drink, except water, until the examination is completed.

Roentgenoscopy.—Six hours later he returns and is taken to the screen room. If the patient is a man he is stripped to his hips; if a woman, she is permitted to wear a thin garment. The patient takes his position in front of the vertical screen apparatus, with his back against the celluloid panel. The operator sits on a stool in front of the patient and the screen. By means of the foot-switch, the room-illumination is turned off and the rays turned on. First, the chest is briefly inspected. Next, the position and distribution of the six-hour meal are noted. Then

the patient takes the aqueous mixture (described in the chapter on General Technic), freshly stirred. While he is drinking this the canalization, that is to say, the manner in which the ingested stream descends to the lower portion of the stomach, is observed. If there is doubt that a given shadow from the six-hour meal represents a gastric retention, the observer notes whether or not the barium-water merges directly with the suspected shadow. When the patient has finished drinking, the contents of the stomach are first driven by the pressure of the operator's hand toward the fundus to outline its contour. Then the contents are pressed toward the pylorus. Some of the barium-water usually is forced out into the duodenum and in this way the location of the pyloric ring can be determined, and the duodenum outlined. The filled stomach is then inspected and its general form, contour, size, position, mobility, flexibility and peristalsis noted; the patient is rotated for different angles of view, and palpatory manipulation is employed as necessary. The oblique view is never omitted, since by this means lesions on the anterior or posterior wall are sometimes discovered when they would fail to show in the postero-anterior view. The tube-box diaphragm is used freely, narrowing the aperture for close study of particular regions. During the screen-examination, special attention is directed to the pyloric portion of the stomach because it is not always well outlined on the plate. If the barium tends to settle away from the pylorus, the ingesta are driven toward the pyloric end by manual pressure. Note is taken of the volume and character of the flow through the pylorus, whether scant or copious, intermittent or continuous. The observer follows peristaltic waves from their commencement to their termination, noting whether they continue without interruption to the pyloric ring, and observing their depth on each curvature. Antiperistalsis is watched for, since its presence is almost always associated with a pathologic condition either of the stomach or the duodenum. It is seen most often in the obstructive lesions at or near the pylorus. If peristalsis is apparently absent, the observer waits a short time for its appearance. Likewise, when duodenal

ulcer is suspected, the study is continued intermittently for several minutes, if necessary, in order that sufficient time may elapse for hyperperistalsis to appear. If pathologic conditions involving the upper gastric pole are surmised, the patient is examined also in the horizontal position. Here the dorsal position offers the better opportunity for palpation, but the patient is examined prone and at various angles in addition. When the screen-examination is concluded, the findings are entered on the blank previously mentioned (Fig. 2).

Plates.—Plates are made immediately after the screen-examination is completed. The patient lies prone upon the cassette, the tube at his back and 45 to 50 cm. from the plate. He is instructed to remain perfectly still and refrain from breathing during the exposure. Eleven by 14-inch plates are used as a rule, but by careful posing 10 by 12-inch plates will often suffice. The 8 by 10-inch size is used generally for serial or multiple plates of the pyloric and duodenal regions. In making plates of the patient lying prone, he is supported by cushions under his chest and thighs if his abdomen is prominent, in order to prevent undue abdominal pressure and consequent distortion. Lesions high in the cardia are sometimes better shown by plates made with the patient on his back or even in the Trendelenburg position. Plates are easily made with the patient standing, and this is done often, though the upper portion of the stomach is not usually well outlined.

The plates are compared with the screen-observations as noted on the fluoroscopic sheet, and the net findings are entered on the permanent record sheet (Fig. 3).

ROENTGEN ANATOMY

The barium-filled normal stomach as seen on the screen or plate differs in many respects from the stomach described in most textbooks of anatomy. However, this does not warrant the conclusion that the textbooks are wrong and that the roentgenologic stomach is an absolute standard. Indeed it has been

urged, and with reason, that the roentgen stomach is to some extent an artefact, that the differing stomachs shown at necropsy, in the opened belly of the living, and by the x-ray, represent nothing else than different conditions of the organ according to the degree of filling, the character of the filling material, whether food, fluid, air or barium, the contraction of the gastric musculature, the degree of rigor mortis, the changes caused by opening the abdomen and, finally, the conformation of the neighboring organs. But the roentgenologist need not concern himself with absolute standards; he is interested rather in roentgenologic bases of comparison.

The stomach described and illustrated in textbooks of anatomy is characterized by the extreme breadth of its cardiac end, the fundus, and the convergence of its walls to form a narrow pyloric portion. The majority of stomachs as observed by the aid of the roentgen ray and with the patient standing do not show this wide difference between the diameters of the cardiac and pyloric segments. On the contrary, the usual roentgenologic hook-form stomach is tubular rather than bulbous, and its pyloric portion, except, of course, immediately at the pylorus, is almost as broad as its cardiac portion. Further, it occupies a position which is largely vertical, instead of largely transverse, as customarily shown in anatomical drawings. A relatively infrequent form of roentgenologic stomach, the steer-horn, lies somewhat crosswise, but it bears little resemblance otherwise to conventional illustrations of this organ.

Anatomists customarily divide the stomach into two parts —a *cardiac portion* (fundus) and a *pyloric portion*—some roentgenologists follow this division. Others prefer to speak of a *vertical* (cardiac) portion and a *horizontal* (pyloric) portion. This is applicable to certain types of stomachs. Most divisions are based on the hook-form stomach, and one of these distinguishes *descending*, *transverse* and *ascending* portions. A convenient division is that used by many roentgenologists, by which the stomach is divided into *pars cardiaca*, *pars media* and *pars pylorica*. The accompanying drawings illustrate these

divisions in both the common forms of stomach (Figs. 53 and 54).

The *pars cardiaca* (fundus, fornix, antrum cardiacum), may be regarded practically as the upper third of the stomach. According to some, its lower limit is marked by the *incisura cardiaca*, the angle above the juncture of the esophagus with

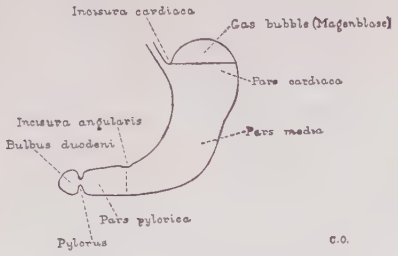

FIG. 53.—Steer-horn stomach.

the stomach. However, the incisura cardiaca is frequently confounded with a shallow indrawing sometimes seen at a considerably lower level on the greater curvature. The pars cardiaca fits snugly under the left arch of the diaphragm. It contains the gas-bubble within its upper convexity. When the stomach is filled, the base of the gas-bubble is marked by the

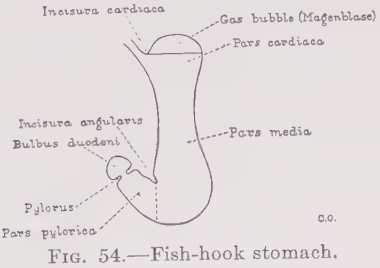

FIG. 54.—Fish-hook stomach.

horizontal plane at the upper surface of the gastric contents. Near the level of this plane, on the lesser curvature, is the esophageal opening.

The *pars media* (body, corpus, pars intermedia), extends from the pars cardiaca to the *incisura angularis*. The incisura angularis is the angle formed on the lesser curvature at the junc-

ture of the pars media and the pars pylorica and is usually well marked in the hook-form stomach. With the institution of peristalsis the incisura angularis is deepened by the peristaltic wave, which passes on and is succeeded by another wave that renews and deepens the incisura. But it is inaccurate to conceive of the incisura angularis as a permanent, non-moving indentation due to muscular contraction. This notion is doubtless related to the idea of an "antral sphincter," which is open to question, as will be seen hereafter. The pars media of the fish-hook stomach descends vertically, or a little obliquely to the right, from the pars cardiaca. Its walls are largely parallel. The pars media of the steer-horn stomach courses obliquely or transversely to the right from the pars cardiaca, and its walls tend to approach each other progressively, to its juncture with the pars pylorica.

The third segment, the *pars pylorica,* is the smallest of the three divisions. It narrows somewhat from its beginning at the incisura angularis to its termination at the pyloric ring. In the fish-hook stomach it occupies a rather vertical position, while in the steer-horn it lies either transversely or obliquely downward.

The term *antrum* (antrum pylori, antrum pyloricum), is often applied to the bulbous expansion of the pars pylorica in front of a peristaltic constriction. Thus its size is variable. In its largest extent it includes the whole pars pylorica, with which the term is sometimes used more or less synonymously.

The pyloric ring shows as a hiatus in the barium shadow, approximately from 0.31 to 0.63 cm. in breadth, between the pars pylorica and the duodenal bulb. When the pyloric sphincter relaxes, the barium flowing through it shows the pyloric canal, centrally placed, and of varying width according to the degree of sphincteric relaxation. While usually the pyloric hiatus can be demonstrated, it may not be shown because of an overhanging bulb, or failure of the barium to pass the sphincter, or an unfavorable angle of view.

The pars cardiaca and pars media of a fish-hook stomach are sometimes spoken of as the *descending arm,* and the pars

pylorica as the *ascending arm.* The length of the ascending arm, and hence the height of the pyloric opening above the lowest point on the greater curvature, is the *Hubhöhe* of Haudek. The upper pole of the stomach is the dome of the pars cardiaca, while the lower pole is the most dependent arc of the greater curvature.

CHAPTER VI

THE NORMAL STOMACH

It is rather trite to say that a knowledge of normal conditions as revealed by the roentgen-ray is essential to a proper understanding of abnormal conditions. Yet this general truth applies so accurately and specifically to the roentgenology of the stomach that its reiteration is never amiss. By this is meant, of course, that there is no standard normal roentgenologic stomach; a most striking fact in its roentgenology. Stomachs which are markedly dissimilar in their roentgenologic characteristics may each be appropriate for its possessor and functionate in a normal manner. Nevertheless, while the appearances of the stomach as seen in the roentgenogram are almost protean, these variations have limits, even though wide, which may be determined in a general way.

In ascertaining whether or not a given stomach is normal, account must be taken of its length, breadth, capacity, contour, position, form, tonus, mobility, peristalsis and motility. These numerous and varying factors not only mutually affect each other, but they are also modified markedly by the general body form—the habitus—of the individual. Who ever has examined a large number of stomachs will realize that certain types of frame-structures are constantly associated with definite types of visceral topography, just as facial characteristics distinguish races. The general "build" of the individual, therefore, becomes a matter of prime importance, and no stomach should be accused of occupying a malposition unless the bodily relationship to visceral form, position, tonus and motility has been taken into account It will thus be seen that the stomach fits the body, that it is not displaced but is a part of a general physical makeup. In the absence of any lesion,

FIG. 55.—Photograph of a person of hypersthenic habitus. Compare with Fig. 57, a photograph of an extreme asthenic (*Dr. R. Walter Mills*).

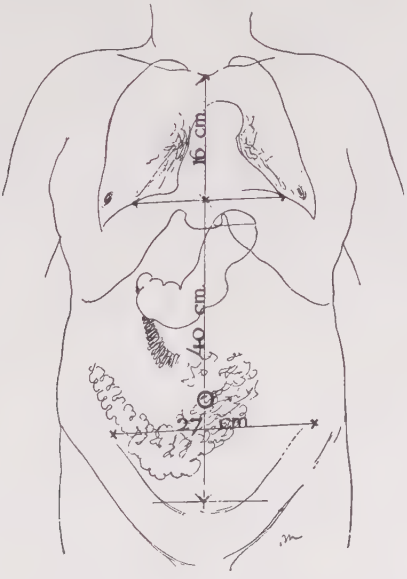

FIG. 56.—An orthodiagraphic visceral study of the hypersthenic subject shown in Fig. 55 (*Dr. R. Walter Mills*).

the stomach functionates in a normal manner; its function is in proportion to the degree of asthenia present and the greater the asthenia the poorer the tonus and the longer the time required for the stomach to rid itself of its contents.

Habitus.[1]—By habitus is meant the relation of bodily build to visceral form, position, tonus and motility. The use of the word here will be limited to the stomach.

FIG. 57.—Photograph of a subject of asthenic habitus. Compare with photograph of hypersthenic habitus (Fig. 55) (*Dr. R. Walter Mills*).

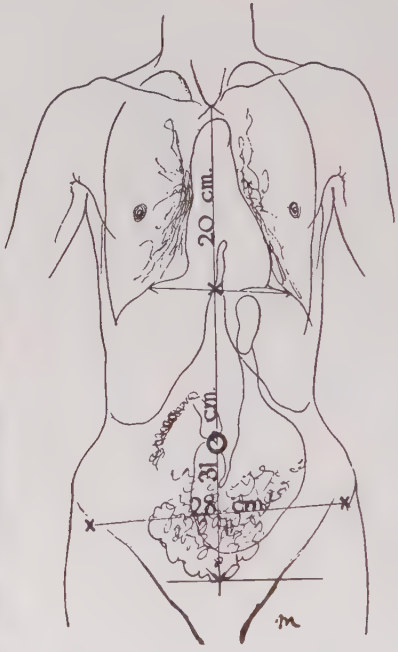

FIG. 58.—An orthodiagraphic study of the person of the asthenic habitus shown in Fig. 57 (*Dr. R. Walter Mills*).

The photographs (Figs. 55, 57 and 59) show the three types of habitus with their accompanying orthodiagraphic types of stomachs. The man in Fig. 55 is a definite example of the hypersthenic, apoplectic or broad habitus person, with robust frame, great body-weight and musculature, long abdomen,

[1] The study of habitus was begun in conjunction with Dr. R. Walter Mills of St. Louis several years ago in the x-ray laboratory of the Medical Department, of Washington University. Dr. Mills continued the work and later published an excellent article on the subject.

short, broad and deep thorax, ribs running almost horizontally to the sides, and obtuse epigastric angle. The lung-fields are widest at their base and become narrower toward their apices, which project but little above the clavicles. The heart occupies an oblique or nearly transverse position. The stomach is high, almost thoracic, and of Schlesinger's hypertonic or Holzknecht's steer-horn type. The pylorus is the lowest part of the stomach. Gastric motility is fastest, and tonus is most

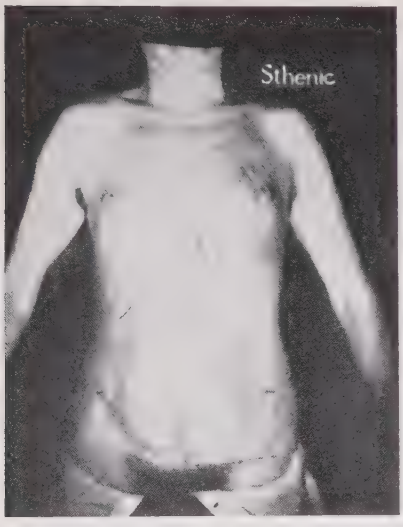

FIG. 59.—Photograph of a person of sthenic habitus. Compare with hypersthenic and asthenic habitus of subjects shown in Figs. 55 and 57 (*Dr. R. Walter Mills*).

FIG. 60.—Orthodiagraphic study of the same person shown in Fig. 59 (*Dr. R. Walter Mills*).

marked in this type. If a low stomach is found in this type there must be a pathologic condition to explain it; a low stomach would certainly be abnormal.

Contrasting strongly with the hypersthenic type of person is the asthenic type—the asthenia universalis congenita of Stiller[2] (Fig. 57)—or enteroptotic habitus. This type differs markedly from the hypersthenic habitus. The asthenic person is of slight build, with a long narrow shallow thorax, steeply

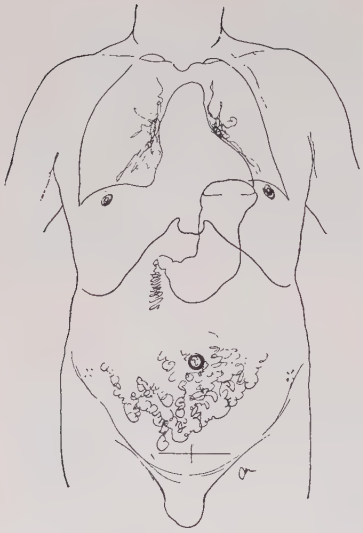

FIG. 61.

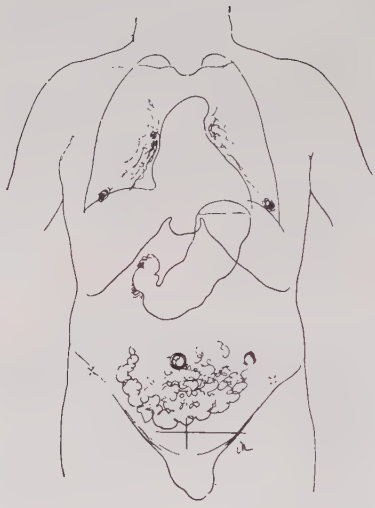

FIG. 62.

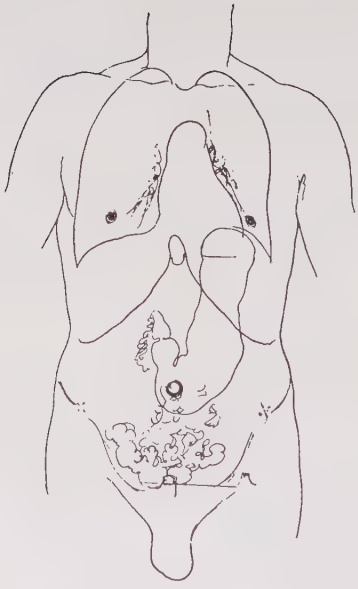

FIG. 63.

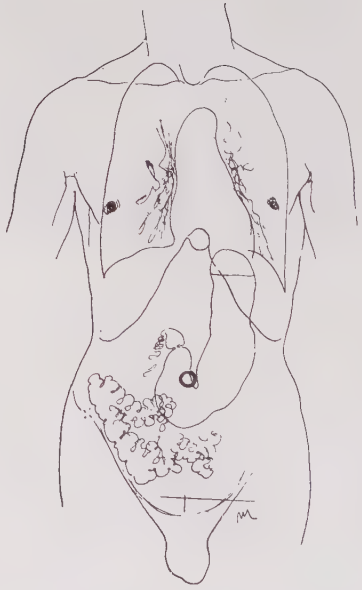

FIG. 64

FIGS. 61, 62, 63 and 64.—Sub- or intermediate types of habitus (*R. Walter Mills*).

falling ribs, wide intercostal spaces, acute epigastric angle, short abdomen, weak musculature, and poor panniculus. The lung-fields are largest in the upper thorax and the apices extend well above the clavicles. The heart is long and occupies a vertical position; the tonus is poorest and the motility is slowest in this type, but even in these asthenic persons the stomach invariably clears itself of the motor meal within six hours. The stomach of the enteroptotic person is usually a long, capacious, vertically lying, relaxed pendulous sac. A high stomach in this type would indicate a lesion either in or about the stomach.

Between these two extremes is the sthenic or normal habitus (Fig. 59); it resembles the hypersthenic type except that the characteristics are less prominent. The stomach is well up in the abdomen and is of excellent tone. The motility is good—somewhere between that of the hypersthenic and the asthenic. This is the orthotonic stomach of Schlesinger.

Between these three types are the so-called sub-types, as seen in Figs. 61, 62, 63 and 64.

The Abdominal Wall.—A second factor which modifies the form and position of the stomach is the tension of the abdominal wall. With a wall of good tone, other things being equal, the stomach and abdominal viscera will be held up at a higher level than if the wall is lax. The markedly flaccid belly, frequently seen in multiparæ, or after the removal of large tumors or ascitic fluid, is often accompanied by extensive ptoses. In Stiller's[2] opinion, the flaccid abdomen has been confounded by some roentgenologists, Holzknecht, for example, with the habitus enteroptoticus, which latter Stiller limits to a congenital form of body with a flat, rather than pendulous belly.

Figure 65 illustrates the effect of relaxation of the abdominal wall. The woman can hardly be described as of the enteroptotic habitus. She is beyond middle age and has borne children. Her abdomen is lax and pendulous, and her stomach is correspondingly long and low-placed.

The tension of the abdominal wall varies not only with its

general tone but also with its degree of active contraction as determined consciously or unconsciously by the patient himself. During examination a phlegmatic person is likely to show his natural and accustomed abdominal tension, while a nervous or apprehensive person is apt to contract his abdominal muscles strongly.

Gastric Tonus.—A third factor affecting the form, position and size of the stomach is the tone of the gastric musculature—its capacity of contracting upon and adapting itself to its con-

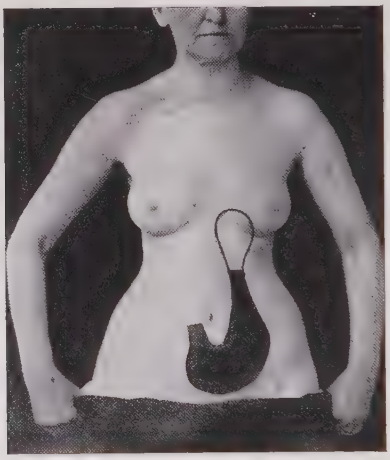

Fig. 65.—Low stomach, the result of abdominal relaxation rather than an enteroptotic habitus.

tents. However, gastric tonus is judged, from the roentgenologic standpoint, largely by the gastric form, position and size, all of which are widely influenced by the habitus, the abdominal tension and other elements. The subject of tone will presently be considered further.

Finally, the form and position of the stomach are influenced to some extent by the conformation of adjacent organs, by the character of the filling material and by its amount.

Thus, the attributes and appearances of the roentgenographic stomach are so closely interrelated that a roentgenologic estimate of any single quality is comparative rather than absolute, and only valid in proportion to the carefulness with which all

contributing elements are considered. Nevertheless, by usage, certain arbitrary bases of comparison have become established, which are convenient, and which will not mislead if they are considered in association with each other.

Form.—As a rule, the normal adult stomach takes one of two general forms, the steer-horn or the fish-hook.

The steer-horn stomach, so-called because of its resemblance to the horn of a steer, occurs much less frequently than the fish-

Fig. 66.—Normal steer-horn stomach.

hook. The steer-horn is seen normally in association with the broad habitus, whether in man or woman, although this type of body is seen most commonly in males. Relatively small, as a rule, it is broadest at the fundus and narrows progressively to the pylorus which is its most dependent portion. It occupies an oblique, sometimes almost transverse, position and lies well above the umbilicus (Fig. 66).

The fish-hook stomach is by far the most common form; it resembles a hook or the letter J. It descends more or less vertically from the diaphragm, curves across the spine, and

ascends to the pylorus, which latter lies above the level of the lowest point on the lesser curvature. It is the usual associate of the slender and the normal habitus, but may occur also with the broad habitus (Fig. 71).

FIG. 67.

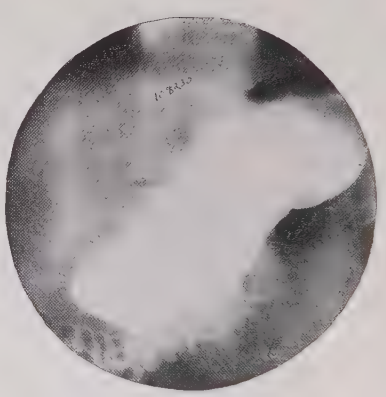

FIG. 68.

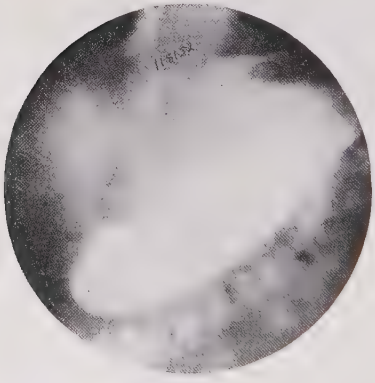

FIG. 69.

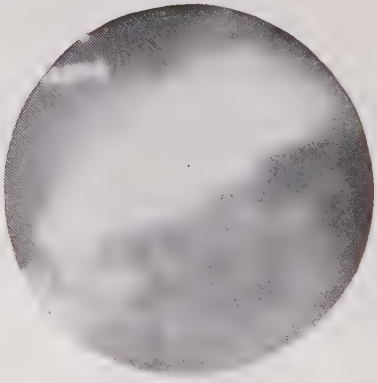

FIG. 70.

FIGS. 67, 68, 69 and 70.—Normal stomachs of steer-horn form.

Between the typical steer-horn and typical fish-hook, forms are sometimes seen which are difficult to classify, as they possess some of the characteristics of both (Fig. 80). Further, what seems to be a steer-horn with a small amount of ingesta, may

assume a fish-hook form if its contents are increased, either because of the sagging produced by the additional weight, or its lengthening to accommodate a greater volume.

Fig. 71.—Normal stomach of fish-hook form.

Holzknecht[3] has defined the normal stomach as one which in the upright position and a filled condition has the pylorus for its lowest point, which is above the umbilicus. It is of steer-horn form with a broad, vertical, cardiac portion and a narrow, horizontal pyloric segment. Holzknecht states repeatedly that the pylorus should be the lowest point, on the ground that this is the optimum for its function. His observations were made in 1906 and are not necessarily represen-

tative of his present views. However this may be, Cannon[4] points out that this conception of the normal stomach rests upon the assumption that the stomach is emptied by gravity drainage. Cannon holds that the contents of the alimentary canal are in exact equilibrium, even in the standing position, that "drainage" in the common usage of that

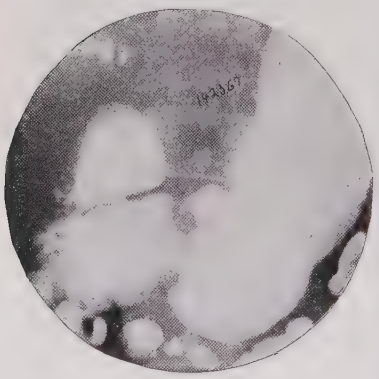

Fig. 72.

Fig. 73.

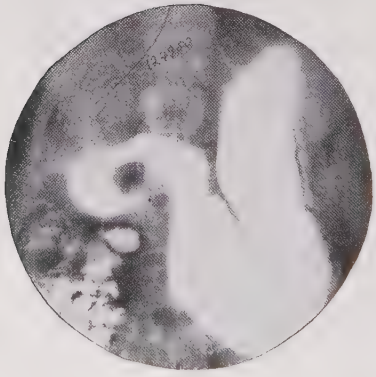

Fig. 74.

Fig. 75.

Figs. 72, 73, 74 and 75.—Normal stomachs of fish-hook form.

term is impossible, and that muscular contraction is necessary to move food onward through the alimentary canal.

Certainly the steer-horn form of stomach is so rare that if this is the only normal stomach then more than 90 per cent of all stomachs must be abnormal. I find it difficult to believe this, since hundreds

of fish-hook stomachs which I have examined were found to be anatomically normal at exploration during the course of an abdominal operation for other conditions. In short, I feel that, barring extreme exaggerations, the general form of the stomach has far less significance than the manner in which it performs its functions.

Fig. 76.

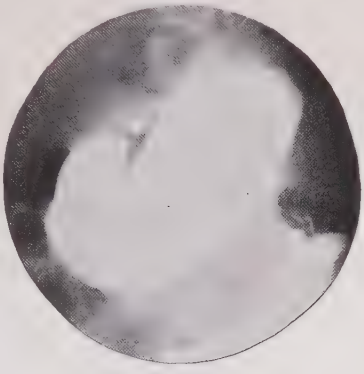

Fig. 77.

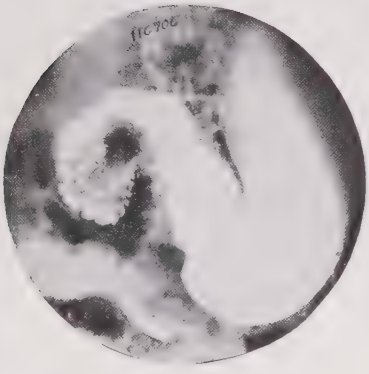

Fig. 78.

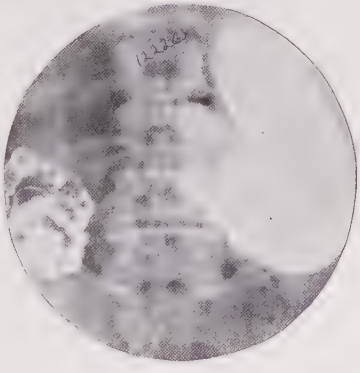

Fig. 79.

Figs. 76, 77, 78 and 79.—Normal stomachs of fish-hook form.

Tone.—According to Schlesinger's[5] classification, which has received rather general acceptance, four varieties of tonus are distinguished—the orthotonic, hypertonic, hypotonic and atonic (Fig. 81). He regards the orthotonic, or normal-toned, stomach as one which contracts on its contents with sufficient force

to maintain a tubular form, even with a moderate amount of ingesta, and he assumes that the orthotonic stomach is normal because most frequently seen and because it performs its functions in a normal manner. It is of fish-hook form and of uniform diameter, its walls being parallel nearly to the pylorus where they converge bluntly, and its lower border is at or near the umbilicus.

The hypertonic stomach, as the term indicates, shows an excess of tonicity. It is short, has a small, flattened gas-

Fig. 80.—Normal stomach of type between the steer-horn and fish-hook form.

bubble, is broadest at the cardia, and its walls narrow steadily to the pylorus, giving it a steer-horn form and an oblique or transverse position. Its lower border is well above the umbilicus. The hypertonic stomach, though relatively infrequent, is not pathologic. Schlesinger regards it as the primary type from which other types have developed by the stretching and sagging of its walls.

His conception of a hypotonic stomach is one which evi-

dences relaxation of its longitudinal muscle-fibers by an increase of length, and consequent sagging downward. The circular fibers are also relaxed and, with the patient standing,

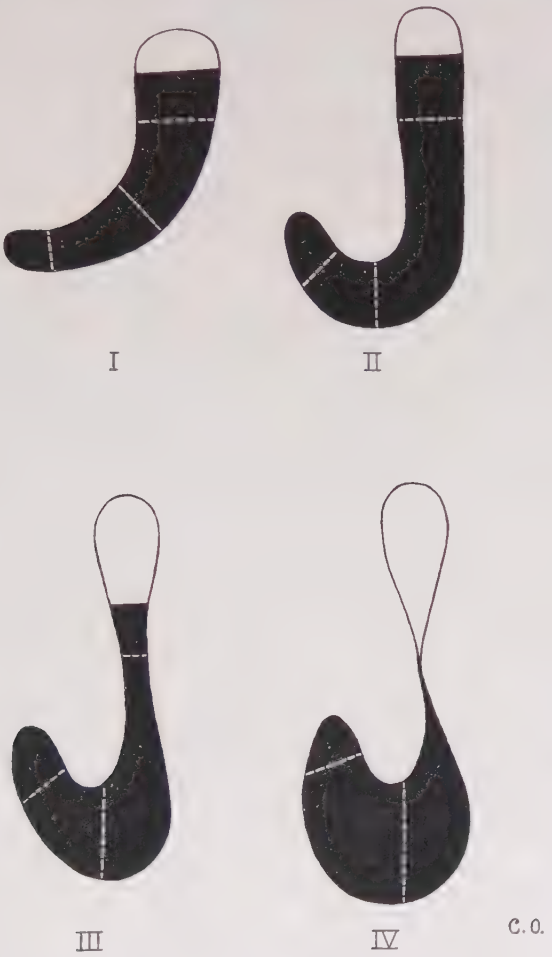

Fig. 81.—Schlesinger's classification of stomachs according to tone. I, Hypertonic; II, orthotonic; III, hypotonic; IV, atonic.

the barium meal broadens the diameter of the lower pole, which sinks below the umbilicus. The upper pars media is somewhat narrowed by the tendency to approximation of its vertical walls.

The atonic stomach shows relaxation to an extreme degree. Ingesta which would completely fill an orthotonic stomach now merely fill the expanded, basin-like lower pole. The vertical walls of the pars media approach each other, closely enough in some instances to retard momentarily the descent of barium. The lower border of the stomach is well down in the pelvis. The gas-bubble, without support below to give it a semilunar shape, appears fusiform. Though not normal, the atonic, as Barclay[6] pertinently remarks, should be discussed in connection with the normal stomach, for it is a "defective physiologic action rather than a pathologic condition."

While Schlesinger's classification is more or less diagrammatic, it serves as a satisfactory scale for comparisons. In its practical application it is subject to the following qualifications:

1. The "atonic stomach" of clinicians is not represented solely by the atonic stomach, for the frequency with which "atony" is used in a clinical sense justifies the assumption that it is applied to all degrees of hypotonus.

2. Schlesinger limits the hypertonic stomach to the stomach of steer-horn shape. But fish-hook stomachs are often seen which are undoubtedly hypertonic as shown by their extremely narrow diameter, shortness, and high position, although the hook-form is retained.

3. He regards only the hypertonic and orthotonic types as normal. In a narrow sense this is perhaps true, but hypotonic stomachs are often seen which are in keeping with the enteroptotic habitus of their possessors, and which perform their functions in a normal manner.

Thus I feel that the chief test by which the stomach is to be adjudged of normal tone is its *correspondence to the habitus of the individual*, and not its form, size and position alone. With the broad habitus the tone may vary from orthotonus to hypertonus. With the normal habitus it may be expected to vary from orthotonus to at least slight degrees of hypotonus. With the enteroptotic habitus, hypotonus is the rule, not only of the stomach, as Stiller has pointed out, but of other organs as well,

and the gastric hypotonus should not be given undue or exclusive stress.

Again, strictly speaking, tonus is an intrinsic quality of the gastric musculature, but the position, form and size of the stomach are modified not only by varying degrees of gastric tone but also by the intra-abdominal pressure and the amount of ingesta. Increased intra-abdominal tension tends to lift up and shorten the stomach; diminished tension tends to lower and lengthen the stomach. Hence the tonicity of the abdominal wall as well as conditions within the belly, such as ascites, pregnancy, new growths, etc., must be considered in estimating the actual tonus. Further, gastric tonus may vary to some extent at different times in the same person, and at different stages of digestion.

Position.—It should be sufficiently clear from the foregoing that the position of the lower gastric pole has a wide range within normal limits, and it may lie well above or well below the umbilicus, the level of which grossly corresponds to a line joining the iliac crests. The position of the lower pole is affected also by respiration, being lowered slightly in inspiration and raised slightly in expiration.

The position of the pylorus varies rather widely with the form of the stomach, the habitus of the individual and the position of neighboring organs. Thus the pylorus of the steer-horn stomach often lies far above the umbilical level, high up in the right hypochondrium. The pylorus of the fish-hook stomach is usually slightly to the right of the median line and somewhat above the umbilicus. But a low-lying stomach may have its pylorus even below the umbilical level and in the median line. The pylorus of an acute fish-hook stomach is often to the left of the median line.

The cardiac end of the stomach does not vary its position normally. Noteworthy is the fact that the stomach descends from the upper pole with a slight obliquity forward so that its lower pole is closer to the abdominal wall than is its upper pole. For this reason the roentgen shadow of the lower gastric segment

is sharper in the anterior view than that of the cardiac segment (Fig. 82).

When the patient lies on his back on the screen-table, the stomach shows a wide, oval pars cardiaca and pars media, while the pyloric portion seems narrowed, or may not be seen at all, thus giving a greater resemblance to the traditional sac-form of the anatomists. In the prone position also, the stomach lies

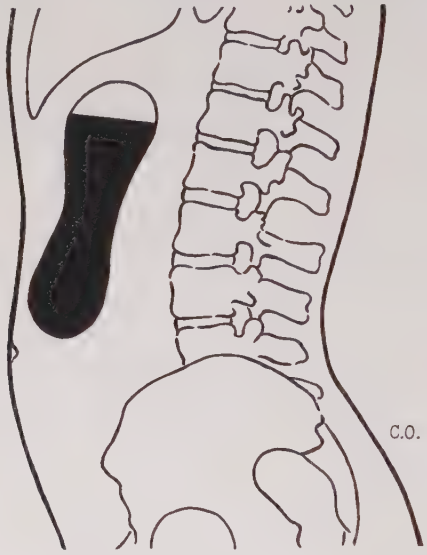

Fig. 82.—Lateral view, diagrammatic, showing the more anterior situation of the lower gastric pole.

higher than when the patient is standing; the cardiac end is broader and the pyloric end narrower.

Size.—The normal stomach is a potential cavity. Its apparent size depends therefore on the volume of its contents. The stomach accommodates itself to an increasing volume of contents chiefly by an increase of width, but partly also by an increase of length. The expansibility in all directions with an increase of the gastric contents is a noteworthy feature of the normal gastric wall. An orthotonic adult stomach will ordinarily accommodate 700 c.c. of a barium mixture without discomfort to the patient and by this amount the gastric periphery

will be effectively visualized. A hypertonic stomach may hold this quantity but with rather evident distention. Capacity is increased proportionately to loss of tone. A 700 c.c. barium meal does not completely fill a hypotonic stomach, but abdominal palpation or the institution of peristalsis may increase the gastric tone until the barium is forced well up to the gas-bubble. In megalogastria the stomach may be of enormous size and yet functionate properly. Ewald[7] mentions one with a capacity of 1680 c.c. On the other hand, the smallest normal stomach he noted could accommodate only 250 c.c.

Contour.—The otherwise smooth and regular contour of the normal stomach is broken by the incisura cardiaca, the incisura angularis and by peristaltic waves. As stated before, the incisura cardiaca is the upper angle at the juncture of the esophagus with the stomach. The incisura angularis is the deep depression on the lesser curvature at the juncture of the pars media and pars pylorica.

On the greater curvature, about where the left costal arch crosses the stomach, a broad, shallow, incurvation is frequently seen, especially if the abdomen is rigid or retracted; it is probably due to the pressure of the abdominal muscles, although some observers have attributed it to the spleen. Hypotonic stomachs also sometimes have a long sweeping incurvation of the greater curvature of the pars media.

The contour of the pyloric end varies with the peristalsis of the antrum, but is always normally symmetrical at any stage of contraction.

Mobility.—The principal fixing supports[8] of the stomach are the esophagus and the gastro-phrenic ligament at its cardiac end, and the hepato-duodenal ligament, about 2.5 cm. beyond the pylorus. Between these points, the dependent body of the fish-hook stomach has a considerable range of passive movement, and by palpatory maneuvers can be lifted up or shifted to either side. By drawing in or relaxing the abdominal wall most patients can raise or lower or even distort the stomach at will (Fig. 83). By deep respiration the filled stomach may be

lowered during inspiration and raised during expiration, the change sometimes affecting the cardia and media chiefly, or it may be slightly raised and lowered en masse.

The hypertonic steer-horn stomach, lying high under cover of the costal arches, between which the abdominal wall is less lax, is not freely accessible to palpation and hence not easily moved about. The pendulous, hypotonic stomach is susceptible of wide shifting. In estimating mobility the relative tension

Fig. 83.—Stomach distorted by strong retraction of the abdominal wall.

of the abdominal wall should be taken into account, accordingly as it facilitates or hinders manipulation.

Flexibility.—An important characteristic of the normal gastric wall is its flexibility. With the abdominal wall fairly relaxed, narrow palpation, *i.e.*, with a single finger or the ulnar side of the hand, on the greater curvature, will produce a sharply outlined indentation closely corresponding to the palpated surface. If the abdomen is held rigid, as often happens, this maneuver is less practicable and less effective.

Gas-bubble.—In the upper pole of the stomach is a quite constant transparent area, the gas-bubble, chiefly due to swallowed air. Its function is thought to be that of keeping the walls of the stomach apart, and thereby little hindrance is offered to the entrance of food. The convex upper surface fits into the concavity of the left diaphragm. With an empty or partially filled stomach its base projects downward like a spindle. With a filled stomach its base becomes a transverse plane, level with the cardiac end of the esophagus. Its size varies considerably and without special significance. In the hypertonic stomach it is usually small and somewhat flattened, while in the orthotonic or hypotonic stomach it is more convex above and larger. In the markedly hypotonic stomach the gas-bubble is fusiform or balloon-shaped.

Secretion.—The amount of secretion in the normal fasting stomach is so small that no accurate estimate can be made during the ordinary roentgen examination. After the stomach is filled with the barium-meal an intermediate layer of fluid may usually be seen between the gas-bubble above and the barium-emulsion below. This fluid is partly gastric secretion but mostly water which has separated from the media employed. Hence the depth of the layer varies not only with the amount of secretion but also with the amount of water which happens to separate, and is not a reliable index of secretory activity.

To determine the amount of secretion in the fasting stomach, Kaestle[9] has made use of Sahli's opaque capsules; one, the "swimming" capsule, floats upon the surface; the other, the "sinking" capsule, falls to the bottom. The vertical distance between the capsules measures the depth of the secretion-pool. However, the total quantity of secretion depends not only upon its depth, but also upon the breadth of the lower gastric pole. It is probable that the amount of secretion can be determined more accurately by the gastro-enterologist's tube than by roentgen methods.

To measure the digestive power of the stomach, Schwarz[10] has employed opaque "fibrodermic" capsules. The capsule

itself is digestible and, when dissolved, releases its opaque contents. The time required for this can be determined by examination at frequent intervals.

Peristalsis.—The ring-like constrictions encircling the stomach which progress to the pylorus and stroke the gastric contents toward the bowel, are seen on the screen as distally moving indentations of the curvatures. Fascinating in interest, subject to alteration both in health and disease, and of high importance in the diagnosis of gastro-intestinal lesions, gastric peristalsis has been given much attention.

Looking over the published descriptions of normal peristalsis as seen by the roentgen-ray, a somewhat disconcerting conflict is noted between the various views expressed. Some of the discordance is doubtless due to a conscious or unconscious effort to harmonize the roentgenologic appearances of peristalsis with certain anatomic conceptions of the stomach, while other discrepancies are perhaps due to technical differences in the manner of observation.

By the older anatomists it was believed that the stomach was partially divided by a transverse muscular band, separating the pyloric portion (antrum) from the remainder of the stomach. This view probably influenced Kaufman and Holzknecht[11] in their description of peristalsis. They observed the peristaltic furrows to deepen as they progressed pylorusward, and reach a maximum depth three or four fingerbreadths from the pylorus. At this place the constriction remains longer as a tonic and more energetic contraction of the gastric wall. The antral portion is completely cut off, they state, and a clear stripe is to be seen between the shadow of the antrum and the shadow of the corpus. The antrum then effaces itself by a process of concentric contraction.

Kaestle, Rieder and Rosenthal,[12] commenting on the above observation and additional quotations from Holzknecht, offer the following contradiction:

> Our investigation shows that during digestion there is no such division of the stomach into two distinct parts, and that a strongly

differentiated antrum pylori in the old acceptation of the term does not exist. As our tracings show, the formation of the new antrum does not commence at the spot where the final emptying of its contents occurs, and is therefore not a mere relaxation of the contracted walls. If we adhere to the idea of an antrum pylori, then it is necessary to speak of two such antra existing side by side and at the same moment. We must speak of an old and a new antrum. As the old antrum disappears, a new antrum is developed from the wall of the body of the stomach. This new antrum passes pylorusward, and ultimately exactly takes the place of the old antrum, whilst another new antrum begins to form. Moreover, if we wish to adhere to the term, our idea of the antrum pylori must be modified. In our opinion, there is no true antrum pylori, any more than there is a sphincter antri, in the sense of the older observers; what we see in the regio pylorica is an increase in the energy of the gastric peristalsis and an increase in the height and depth of the wave-summits and depressions. Just as the roentgen examination shows no trace of a sphincter antri, so anatomy fails to show any trace of a transverse muscular band, or anything in the nature of a true sphincter.

The observations of Kaestle, Rieder and Rosenthal were made by bioroentgenography, a modification of kinematography. Twelve or thirteen plates were exposed during the course of a single peristaltic contraction—about twenty-two seconds—shortly after the ingestion of a bismuth meal. These plates show a continuous progression of the peristaltic waves to the pyloric ring. By superposing tracings of these plates a composite was obtained showing graphically the successive positions occupied by the wave. The wave is shown to begin at the incisura cardiaca, whence it travels pylorusward with slightly, but steadily, increasing depth. At no point is the stomach completely segmented (Fig. 84).

Cannon[13] cites the work of Kaestle, Rieder and Rosenthal as substantiating his own early contention that the pyloric end is normally not separated from the rest of the stomach, and that the waves are continued over the vestibule. Further on, however, he adds: "As digestion proceeds, the constrictions in the region of the vestibule grow still stronger, and finally, when the stomach is almost empty, they may, as they come near the

pylorus, completely divide the cavity. At all times, in the close neighborhood of the pyloric canal, the circular and longitudinal fibers, both of which are here strongly developed, probably coöperate to decrease simultaneously in all directions the terminal segment of the stomach."

Groedel[14] has noted several varieties of peristaltic movements, including very shallow waves, deep waves, and local contractions of the gastric wall. The shallow waves come on

Fig. 84.—Composite diagram showing gastric peristalsis. (By Kaestle in Rieder-Rosenthal's Roentgenkunde.)

soon after the ingestion of food, travel rapidly, and are hard to see with the naked eye. The deep wave-movements are seen on the greater curvature, begin below the incisura cardiaca and end at the sphincter antri. The local contractions remain for a longer time, sometimes simulating hour-glass contraction, and he was unable to say whether they are normal or pathologic. He accepts the theory of a concentric antral contraction.

Avoiding the terms "normal" or "abnormal," Cole[15] has made a study of "unobstructed peristaltic contractions," as shown by a series of roentgenograms. He introduces the

term "gastric cycle," there being as many "gastric cycles" as there are peristaltic contractions visible at the same time. Thus he notes one, one-and-a-half, two, three and four-cycle types, and regards the two latter as the more common. He holds also "that the gastric motor phenomenon is complex, rather than simplex, as evidenced by a systole and diastole of the stomach in addition to the peristaltic contractions passing pylorusward."

Making due allowance for possible slight variations resulting from different technics, the observations of Kaestle, Rieder and Rosenthal offer the simplest and most logical explanation of peristalsis, as I have seen it by the x-ray, although I was at one time inclined to accept Holzknecht's theory of a concentric antral contraction. The division of the stomach by physiologists into two portions with largely different functions may be freely granted, but the peristaltic phenomena that I have observed do not warrant the assumption of a sharp anatomical division between these two portions. It may be that the thick musculature of the vestibule undergoes some general contraction other than that of the advancing wave, but, if there is such contraction, it is so slight that it cannot be determined and the advancing peristaltic ring completely dominates the view. The introduction of "gastric cycles," each with its "systole" and "diastole," seems to me a needless complication of the matter, for I am unable to see any close similarity between the action of the stomach and the action of the heart. In the stomach there is no general systole as in the heart, but a localized moving peristaltic contraction; nor is there a general diastole, the gastric contents merely following up the advancing wave.

The fact that the gastric musculature in addition to its circular fibers contains also longitudinal and oblique fibers, justifies the presumption that these latter participate in the motor functions of the stomach. But it seems that this participation is shown chiefly by a heightening of tone, with a closer embrace of the gastric contents (peristole) which continues all through the period of peristaltic activity, and is

further manifested in the symmetrical shrinking of the stomach as its contents are evacuated.

During the first five or ten minutes after the stomach has been filled with the opaque materials previously described, the peristalsis that is seen most commonly on the screen is limited to the pyloric portion of the stomach (Fig. 85). First is noted a slight deepening of the incisura angularis. Then on the greater curvature, opposite the incisura, a complementary depression

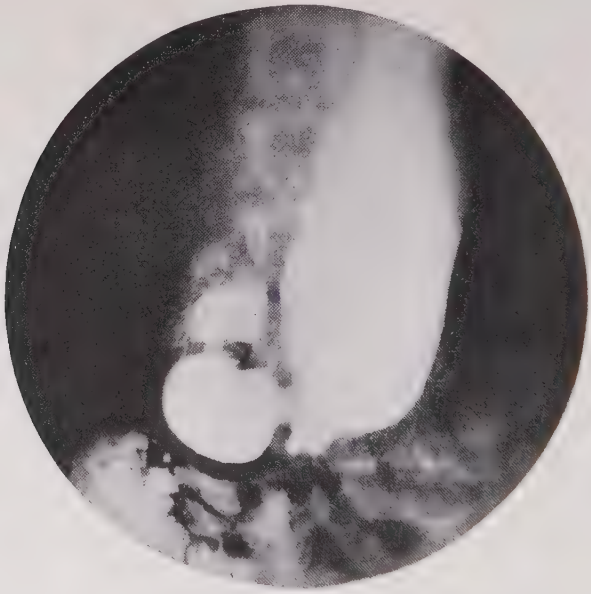

Fig. 85.—Single peristaltic wave, pyloric portion.

is seen. The encircling constriction deepens, then moves slowly pylorusward. The vestibule (antrum) is not completely segmented and the vestibular contents escape backward through the advancing ring, save for a small amount which may be driven through the pylorus. The wave continues its journey to the pylorus, and, as it disappears, another wave is seen forming at the incisura angularis. Less frequently the wave begins in the pars media a little above the incisura angularis, its depressions are visible on both curvatures, and it forms while its

predecessor is sweeping over the vestibule (Fig. 86). Thus only one wave, or at most two waves, can be noted as a rule, during the period mentioned.

Peristalsis is sometimes a trifle delayed in its appearance after ingestion of the meal. Its advent may also be retarded by certain nervous states of the patient, such as fright or disgust for the meal. It may sometimes be induced by massage and

FIG. 86.—Peristaltic wave, pyloric portion; second wave forming in body of stomach.

quite vigorous peristalsis may thus be elicited, but it dies away quickly when the stimulus ceases. Although the experiments of Cannon on animals and the observations of others on man indicate that peristalsis continues without interruption until the stomach is empty, I have occasionally noticed an intermittence during the early period after ingestion; the activity alternating with absolute or comparative rest.

The depth of the wave varies not only among individuals, but also in different parts of the stomach. In the pars media on the greater curvature, the wave-depression is relatively

broad and shallow, while its fellow on the lesser curvature is scarcely visible above the incisura angularis. Both depressions increase in depth as they approach the pars pylorica. From the incisura angularis to the pylorus the waves vary little in their depth, and are quite similar on both curvatures. The energy of contraction is affected somewhat by tone; it is greater in the hypertonic and less in the hypotonic stomach; it is likely to be increased with hyperacidity and diminished with achylia and fatty ingesta, and it is perhaps a trifle more active with barium than with bismuth. Activity is also increased by a prone position of the patient, and two or three waves may be seen at one time.

Ordinarily, waves succeed each other at regular intervals and hence with regular interspaces as noted on either curvature. On the greater curvature the depressions are farther apart than on the lesser curvature, the constriction tending to maintain a plane perpendicular to the curving long axis of the stomach.

The time required for a wave to run its course depends partly at least on where it begins and the distance to be traversed. Twenty-two seconds has been stated by Kaestle as the average time of transit. His composite drawing shows the wave beginning high up at the incisura cardiaca.

Motility.—The testing of gastric motility by the roentgenologic method has been of striking value in my own work. Before discussing this feature of the roentgen examination it may be well to recall some of the elementary facts as to the physiology of the gastric motor function. In this respect much of the inspiring work of William Beaumont[16] remains uncontradicted to this day. For example he found that "the time required for the digestion of food is various, depending upon the quantity and quality of the food, state of the stomach, etc.; but that the time ordinarily required for the disposal of a moderate meal of the fibrous parts of meat, with bread, etc., is from three to three and a half hours." Further, he drew the "inference," as he expressed it, "that oily food is difficult of digestion" and that "water, ardent spirits and most other fluids are not affected

by the gastric juice, but pass from the stomach as soon as they are received."

Of the more recent investigators, Cannon,[17] by his painstaking experiments on animals, has given us reliable data, among which may be summarized the following: The chyme does not pass through the pylorus at the approach of every peristaltic wave, but emerges occasionally, at irregular intervals, of from ten to eighty seconds. Acid above opens the pylorus and acid below closes it. Fats when given are almost invariably present in the stomach during seven hours' observation. Water begins to enter the intestine almost as soon as it enters the stomach. Carbohydrates go through rapidly; proteins more slowly. When carbohydrates and proteins are given one after another the early rate of evacuation is largely the same as that of the first food given. Mixtures of carbohydrates and proteins have an emptying rate intermediate between that of carbohydrates and that of proteins. Fat retards the exit of either food-stuff from the stomach into the intestine. As to consistency of food materials, there is a marked retardation of the outgo of food from the stomach when hard particles are present. Considerable amounts of gas in the stomach retard the discharge of food. Rage, distress, anxiety, grief, anger and violent emotions have a depressive effect on gastric motor activities.

Besides the physiologic variations to which the gastric clearance time is subject, it may, of course, undergo numerous pathologic alterations, in the direction either of an exaggeration or a diminution of motility.

It would seem that by no simple test can sharp and constant lines of demarcation be drawn between hypermotility, normal motility and hypomotility. Nevertheless, extreme variations in either direction, more especially toward hypomotility, have high diagnostic significance; they can be determined at least broadly, and efforts at such determination cannot safely be neglected. The method in most common vogue of testing gastric motility is the administration of a meal and the use of the stomach-tube to ascertain whether food remnants are present

after the lapse of a certain time. The following citations will give a fair idea of this method.

Kemp[18] states that the impairment of the motor power is fully as important, if not more important, in many cases than damage to the secretory functions. He describes various test-meals used in gastric analysis including those of Riegel,* Ewald,† and Leube‡ and the test-breakfast of Ewald-Boas.‖ Regarding the specific question of motility he remarks:

> If five hours after a test-meal, a small amount of chyme is aspirated the motor power is good. If large quantities are found six hours after the meal the motor function is absolutely (or, if stenosis, relatively) decreased * * * Some employ the test-breakfast. Two hours later the stomach should be empty. If 100 c.c. or more are found at the end of an hour, or varying quantities at the end of two hours, it shows different degrees of motor insufficiency. The test-meal is more accurate. I sometimes administer a test-supper and aspirate in the morning to test the motor function, following immediately with the test-breakfast to examine the secretory function.

Kemp also describes without comment the motility tests with salol (Sievers and Ewald),[19] iodipin (Heichelheim),[20] and oil (Klemperer).[21]

Bassler[22] mentions as of value the Leube-Riegel test-dinner, consisting of beef-broth, 400 c.c.; beef, 150 gm.; pure or mashed potatoes, 50 gm.; and a roll of wheat bread. The exit of this meal from the normal stomach should occur within five hours. But he goes on to say:

> A word of caution should here be given in assuming the existence of pathologic conditions when five or six hours afterward small quantities of food are extracted, for, while the great bulk of the meal is gone, tarrying remnants of food may be present even in the perfectly normal stomach up to the sixth and even the seventh hour after the

* Riegel's test-dinner: Meat broth, about 400 c.c.; beefsteak, 150 to 200 gm.; mashed potatoes, 50 gm.; and a roll (35 gm.).

† Ewald's test-meal: Finely chopped meat, 175 gm.; stale bread, 35 gm.; and butter.

‡ Leube's test-meal: A plate of soup, a beefsteak and a roll.

‖ Ewald and Boas' test-breakfast: One or two rolls (35–70 gm.); one cup of tea or water (300–400 c.c.); given in the morning in the fasting condition.

time of ingestion. If at the sixth, seventh or eighth, or any succeeding hour of extraction after the taking of a mixed meal, considerable quantities of the meal constituents are obtained from a stomach, the existence of the following conditions should be considered, namely: Pyloric obstruction, states of atony, a more or less low state of digestive disturbance from degrees of subacute and chronic gastritis accompanied with poor gastric function, and the existence of neurotic conditions of a depressing type affecting the entire motility of the organ. Another form of examination by the extraction of gastric food contents to diagnose pyloric obstruction from any cause (particularly its high degree seen in malignancy) should be mentioned. In this the generally employed procedure is to advise the patient to eat a full meal in the early evening, and then to wash out his stomach the following morning—about ten or twelve hours afterward. Should the patient not have vomited during the night, and food remnants be found in the morning, bona fide pyloric stenosis can almost invariably be diagnosed.

Bassler states further that a simplification of this method, which he can endorse as of much value, is the eating of several raisins* in the evening and noting if their skins or seeds are obtained in the morning lavage water. While in this test the obtaining of vegetable skins is of much significance, a negative result does not always mean that no stenosis exists. A less complete degree of stenosis, particularly in the pyloric region but not directly at the pylorus, may give positive results with the six, seven or eight-hour extraction of the mixed meal, but may give a negative finding with the raisin-skin method. The matter, he thinks, is entirely one of degree; the nearer the stenosis to the pylorus, the more accurate are the results by both methods; the less the degree of the stenosis, or the farther away from the pylorus it is situated, the better is the result from the mixed meal, and the less so from the raisin-skin method.

Einhorn[23] gives a fair summary of gastro-enterologic methods in common use when he says:

*Bassler speaks of this as the "Mayo method." In fairness it should be said, however, that the addition of raisins to the Riegel meal is credited by Cohnheim ("Diseases of the Digestive Canal," Edit. 2, Philadelphia, J. B. Lippincott & Co., 1911, p. 35), to Boas.

The best and easiest way to test the motor function of the stomach is to examine this organ by means of the tube and lavage in the morning in the fasting condition after the ingestion of a substantial supper on the night previous. Normally the stomach is empty, and therefore when the organ is found to contain a quantity of food, this is the best sign of retarded motion.

Roentgenologic Tests of Motility.—Since the first employment of the roentgen-ray in conjunction with an opaque meal for the diagnosis of gastro-intestinal disease, more or less attention has been directed to gastric motility. By a few men this feature of the examination is considered almost indispensable; by others it is regarded as of secondary importance, though usually given some attention, while a few deem it of little moment.

As might be expected, an investigation of the technic used by different roentgenologists shows considerable variance. Wide differences are noted as to:

1. The opaque salt used.
2. The character of the vehicle.
3. The proportion of opaque material to the medium of suspension.
4. The total quantity administered.
5. Management of the patient with regard to eating after the opaque meal has been taken.

Mention has been made elsewhere of the various opaque salts used, including the subcarbonate and oxychloride of bismuth, zirconium oxide, barium sulphate, etc. So far as may be discovered from the published observations of others and from my own experience there seems to be little difference in the evacuation time of the various bismuth salts when they are given under equal conditions; but the difference in this respect between bismuth salts and barium sulphate is marked, the latter leaving the stomach distinctly earlier. Groedel's[24] figures also indicate that with barium sulphate the stomach empties itself much faster than with bismuth.

The vehicles employed have been of every sort conceivable,

including water, milk, mucilage of acacia, bread and milk, cereal porridges, paps and gruels, mashed potatoes, fermented milk, and mixed meals containing meat. The proportion of opaque salt to suspension medium varies from 10 to 50 per cent. of the former, and the total quantity of the meal given ranges from 180 to 600 gm. or more. Finally, practice differs as to permitting the patient to follow his accustomed habits of eating and drinking during the period of examination. Often this important feature is not mentioned, yet it is known that the taking of food after ingestion of the opaque meal will markedly prolong the evacuation time of the latter.

It is quite apparent that from these differing technics, differing results must follow and this undoubtedly accounts very largely for the varying esteem in which roentgen tests for motility are held.

The prototype of all the opaque meals now in use was that devised by Rieder,[25] and consisted of 50 gm. of bismuth carbonate in 350 gm. of flour-pap. Rieder considered three to four hours as the normal emptying time for this meal. Usually half the meal is discharged within an hour. Toward the end of digestion, he notes that there is a distinct slowing of emptying which he thinks is due to an intestinal reflex. He mentions the experiments of Wulach showing the emptying time of carbohydrate mixtures to be from two and one-half to three and one-half hours, albuminous mixtures five to six hours, and fat from seven to eight and one-half hours. The roentgen method gives a good picture of gastric motility. But, Rieder adds, in spite of the great excellence of the roentgen motility test, the method formerly used alone of withdrawing a test-breakfast or test-meal will firmly retain its diagnostic worth because it will show in every case not only the motility but also the secretory function.

Barclay[26] has used bismuth carbonate in the proportion of 1 to 2 or 3 of the excipient, for which latter he employs bread and milk, thoroughly mashed up, or porridge. The total quantity given varied from 60 to 350 gm. With regard to motility he says:

Retention of bismuth food is the result of pyloric obstruction and Rieder laid it down that the whole of a bismuth meal should have left the stomach within five hours. For diagnostic purposes this is a good enough guide, but I never report definite obstruction unless the delay is well marked. In hospital practice eight hours' retention is my standard, but in the vast majority of the cases recorded, some food was still present in the stomach after twenty-four hours. In private practice six hours is my standard, but I always repeat the observation on at least one occasion to verify this finding when the margin of delay is so small.

Groedel[27] at first employed the Rieder carbohydrate meal. An emptying time beyond four hours he regarded as abnormal. Later[28] he began using barium sulphate 250 gm., mixed with 20 gm. each of maize flour, sugar and cocoa in 400 c.c. of water. This meal, he found, emptied normally in two hours.

Kaestle[29] considers two and one-half to three and one-half hours as the normal emptying time of a fluid, carbohydrate (mondamin), contrast meal containing zirconium oxide and weighing 400 gm. A stiff mixture of the same weight may require four hours. Slight delay of evacuation of the fluid meal, up to six hours, he states, may be caused by gastric atony, hyperacidity, reflex pylorospasm, and even beginning pyloric stenosis. Residues after twelve hours or longer occur only with organic pyloric stenosis. Hypermotility may result from a gaping pylorus or strong expulsive energy (hypertonus and hyperperistalsis).

Satterlee and LeWald[30] in their description of the water-trap stomach demonstrated the occurrence of a residue from the bismuth meal in many of these cases. "The water-trap stomach," they say, "might almost be considered as a ptosed organ, with the first portion of the duodenum and the pylorus fixed in proper position, giving the characteristic long pyloric arm and the resemblance to a water-trap." The meal given consisted of 90 gm. of bismuth subcarbonate suspended in 600 c.c. of fermented milk. A residue from this meal, "long after the usual emptying time" was noted in 50 per cent. of the cases.

Cole[31] states:

I have already shown the fallacy of testing the gastric motor efficiency by administering bismuth suspended in fluid or mixed with cereal, and the same is true for intestinal motor efficiency. If the test is to be of value the stomach and intestines must be called on to evacuate such a meal as is normally imposed on them. Therefore, the true test of gastro-intestinal motor efficiency is made by administering bismuth or barium suspended in fluid, preferably buttermilk, in conjunction with a Riegel meal of meat, potatoes and bread. . . . If the stomach is high and of the cow-horn type, especially if a condition of diminished acidity or achylia exists, evacuation will be accomplished very rapidly, perhaps in two hours, whereas many a stomach presenting no organic obstruction requires six hours for complete evacuation.

Baetjer and Friedenwald[32] gave a meal consisting of bismuth subcarbonate, 45 gm.; in an ordinary glass of water (about 350 c.c.) with sufficient mucilage of acacia to make an emulsion. They regard from three to four hours as the normal emptying time for a horizontal stomach, and from five to six hours for a prolapsed fish-hook stomach.

George and Gerber[33] call attention to the composition of the original Rieder meal and the fact that other mediums and much larger amounts of the opaque salts came into use. They offer this comment:

As a result of the marked variation of bismuth meals it is impossible to use the same functional data for diagnosis. . . . This is a point which has not been appreciated by many roentgenologists. They have used various kinds of meals—not only buttermilk, but malted milk, plain milk, water, mashed potato, etc., and have varied the amount of bismuth or barium, and yet have attempted to apply to their work the conclusions based on the observation of functional disturbances in thousands of cases done under the Rieder technic. Obviously this is incorrect. The only proper course left for one who wishes to use these functional data is to accumulate a large number of cases, done with more satisfactory mixtures and check them up with operative results.

In a paper written a few months prior to the above, George and Gerber[34] venture this statement: "The more we have accu-

mulated evidence on this subject, the more we have become convinced that six-hour gastric stasis is the least important factor in roentgen bismuth diagnosis." Recently they[35] have reiterated this opinion. It should be noted that with their technic the patient is permitted to take food during the six-hour period.

As a test of motility in those cases in which the stomach-tube is contraindicated or refused, Bassler[36] uses a mixed-meal method giving 25 gm. of bismuth subcarbonate with the Riegel meal and examines by the roentgen-ray six hours later, at which time the stomach should be empty. In marked pyloric stenosis he has noted a residue at twelve hours, or much later, even to five days. However, in a subsequent publication, Bassler[37] has this to say:

> In the study of motility and exit from the stomach in 203 cases of distinct gastroptosia, in which hourly roentgen-ray observations were made, the conclusion was plain that the roentgen-ray method of diagnosing stasis in the stomach is not as practical as the test-meal method. One hundred and twenty-six of these cases examined by the bismuth-roentgen-ray method showed delay of exit of six hours or more, while only 31 showed the delay by the test-meal method. . . . Instances were encountered in which bismuth was present in the stomach as late as eighteen hours after ingestion, while the stomach on a mixed meal was empty in four and one-half hours. . . . It is apparent, whatever has been advanced to the contrary, that the method of examination by food extraction is decidedly more to be depended on in gaining an idea of exit from the stomach than is the bismuth-roentgen-ray method, for it was strongly suggested that foods pass from the stomach in decidedly less time than will bismuth or any other form of metal salts used to throw a shadow, probably because of the pulverized salts adhering to the mucosa.

The most faithful advocate of the roentgen motility test is Haudek,[38] and to him we are indebted for the double-meal method of examination, the establishment of the six-hour limit and a vast deal of information concerning the significance of disordered motility as shown by the roentgen-ray. The rather chaotic application of the roentgen examination for motility led Haudek, in 1909, to establish his double-meal method, partly with the

view of saving time and partly to make the test more precise. Accordingly, he began the administration of a Rieder meal in the morning, and examined the patient six hours later, at which time a second Rieder meal was given to complete the examination. The selection by Haudek of six hours as the division line between normal and delayed emptying was explained by him on the ground that while the normal stomach will drive out a Rieder meal in about three hours, as an average, delay to five or six hours might result from physiologic causes. He cited as examples the influence of rest and movement, right and left-side positions, psychic factors, eating or drinking after taking the meal, and sedimentation of the opaque salt. Even after six hours or longer, minute residues might sometimes be found in normal stomachs, and he accordingly ignored mere traces. Small residues, up to a quarter of the meal, he deemed, could be due not only to organic pathologic changes but also to hypomotility from atony, hyperacidity, or long *Hubhöhe*, that is, a long, vertical pars pylorica. Larger residues could be almost certainly ascribed to pyloric obstruction by organic stenosis or spasm from ulcer. He also pointed out that the test did not rest alone on the presence or absence of a residue, but that the position of the "head" of the six-hour meal gave gross information as to motility. Normally, at or near the cecum, the "head" would be advanced far into the large intestine by hypermotility or held back in the small intestine by hypomotility. Further, on giving the second meal, there could also be taken into consideration the tonus of the stomach, its peristalsis, the freedom of passage through the pylorus, the *Hubhöhe*, and thus the total picture would enable an estimation of "the great 'X' of motility, the functioning of the pylorus."

An experience of years with thousands of cases has increased Haudek's confidence in the method. In a recent article, he[39] goes so far as to say that the roentgen determination of the expelling forces of the stomach gives better results than the older methods, and that it is not only exact and reliable but also very simple. He shows that while the clinical examination cannot

determine whether the increase or decrease of motility is due to a change of the expelling power or of the resistance, the roentgen examination can be much more decisive. While he had previously considered atony to be an occasional cause of six-hour retention he now believes that atony, under otherwise normal conditions, causes only a slight lengthening of evacuation time, usually below six hours. The most important factor for the evacuation of the stomach is the condition of the pylorus. Lessening of resistance produces the picture of pyloric insufficiency; an increase leads to the highest degrees of stagnation.

For more than seven years past my work has been based on the double-meal method of Haudek, and I can unreservedly endorse his claims. For various reasons I have found it advisable to modify his technic in some particulars, but have retained the six-hour limit and adhered rather closely to his general principles. A cereal porridge instead of a pap for the six-hour meal is employed and barium sulphate substituted for bismuth salts. (For detailed technic refer again to page 29.) Since barium leaves the stomach earlier than bismuth I believe that a six-hour retention of barium is even more significant than one of bismuth. Until the beginning of 1914 patients were required to take castor oil in the evening previous to the day of examination, but this has been abandoned as unnecessary. The observations of Hayes[40] show that purgation results in a heightening of gastro-intestinal motility for a day or two. A comparison of my observations since 1914 with those made previously, indicates that this increase does occur, but that it does not materially affect the six-hour test.

With the stomach empty at the end of six hours and the head of the motor meal anywhere from the cecum to the hepatic flexure the gastric motility is considered normal, at least so far as the net result is concerned. It does not follow that this finding absolutely excludes any disturbance of either the active or passive factors of motility, since a diminution of one may be offset by an exaggeration of the other. For example, a somewhat stenotic pylorus or duodenum may be balanced by vigorous

gastric peristalsis, or an achylia; or a so-called atonic stomach with weak peristalsis may evacuate its contents through an unusually patent pylorus in average time. Hence a stomach that is empty at six hours, with the motor meal at or not far beyond the cecum, is, strictly speaking, normal as to motility only on condition that other elements are normal also, that is, acidity, peristalsis, tonus and pyloric functioning. If any of the latter are definitely abnormal, the presumption is that one abnormality is compensated by some other, and an analysis of the complication may promote diagnostic accuracy. With our present limitations, however, a calculation of this sort could easily lead to error by its intricacy. Likewise, between the average emptying time of say three hours and the arbitrary limit of six hours allowed for presumptively normal evacuation, is a rather wide zone for the play of physiologic and, occasionally, pathologic factors causing hypomotility. It was precisely to make liberal allowance for these that Haudek drew his line at six hours, and for this reason I have adhered to that line, though my meal probably leaves the stomach earlier than Haudek's. If there is error it is, at all events, on the side of safety.

A degree of hypermotility, as evinced by advancement of the meal beyond the hepatic flexure and by rapid discharge of the second meal through the pylorus, not rarely has a physiologic explanation, as, for example, a hypertonic, steer-horn stomach. But marked hypermotility should stimulate a search for possible pathologic causes.

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CHAPTER VII

THE ABNORMAL STOMACH

Form Variations.—Other things being equal, the general form of the stomach should correspond to the habitus of its possessor, and an inharmonious combination demands explanation. Thus, the steer-horn form of stomach, which is sometimes seen normally in the hypersthenic habitus, is to be regarded with suspicion if seen in association with the asthenic habitus, and the possibility of a carcinoma or other lesion should be investigated. On the other hand, the occurrence of a fish-hook stomach in a person of the broad habitus is not necessarily significant, unless the stomach be also hypotonic and elongated.

The form of the stomach has some slight indicative value in predicating the nature of a lesion which may possibly exist. For example, ulcer is rarely found in a steer-horn stomach; by far the larger number of ulcers that I have seen occurred in the fish-hook type. In fact, the steer-horn type of stomach, which is itself infrequent, rather seldom shows lesions of any sort. The apparent steer-horn occasionally seen in advanced scirrhous carcinoma is, of course, a result of the pathologic process. The hook-form is often preserved in medullary carcinoma of the stomach. A snail-form of the stomach, with acute flexion of the pyloric end toward the lesser curvature is found occasionally in gastric ulcer.

Marked distortion and deformity of the stomach may occur with gastric carcinoma, tumors, whether intrinsic or extrinsic, syphilis, ulcer, spasm, ascites, or increased intra-abdominal tension from any cause, including voluntary contraction of the abdominal muscles.

Changes of Contour.—Irregularities of the gastric outline are of the highest importance in roentgenologic diagnosis.

These alterations consist either of localized additions to or subtractions from the visualized gastric lumen.

As examples of the former we have the *niche* of penetrating ulcer and the *accessory pocket* of perforated ulcer. The niche represents the crater of the ulcer, varies in size from 2 to 3 mm. to 2 to 3 cm. or larger, and shows as a direct extension of the luminal shadow (Fig. 87). It is nearly always located on the lesser curvature or posterior wall between the incisura angularis and the cardia; it is rarely found on the anterior wall or greater curvature. The accessory pocket is an excavation produced by the extension of a perforated gastric ulcer into adjacent tissue, usually the pancreas or the liver (Fig. 88). It shows as a shadow varying in size, outside of but near the gastric lumen. Its channel of communication with the latter is not easily demonstrable. Its own contour may be symmetrically rounded or irregular. Portions of the opaque meal in the bowel adjacent to the stomach may occasionally simulate a niche or pocket, but a change in the position of the patient and abdominal manipulation will usually show the true condition. The bulge between two peristaltic wave depressions close to each other on the lesser curvature has a superficial resemblance to a niche except that it advances with the progress of the waves, while a niche remains stationary.

Localized subtractions from the gastric outline, known as *filling-defects*, may be actual and permanent if due to lesions involving the gastric wall, or apparent and non-permanent if due to extraneous conditions. Actual filling-defects are noted in carcinoma (Fig. 89), syphilis, benign tumor, varicosities and adhesions. Apparent filling-defects may result from gas or feces in the adjacent bowel (Fig. 90), extrinsic tumors (Fig. 91), spasm of the gastric musculature, extreme intra-abdominal pressure, fluid pent up in the pyloric end of the stomach, food remnants or foreign bodies in the stomach, faulty opaque mixtures separating irregularly, or the pressure of a kyphotic or lordotic spine. On the plate the displacement of the visualizing meal, resulting from compression of the stomach against the spine

FIG. 87.—Penetrating ulcer. Niche at *a*.

FIG. 88.—Accessory pocket at *a*, due to perforated ulcer.

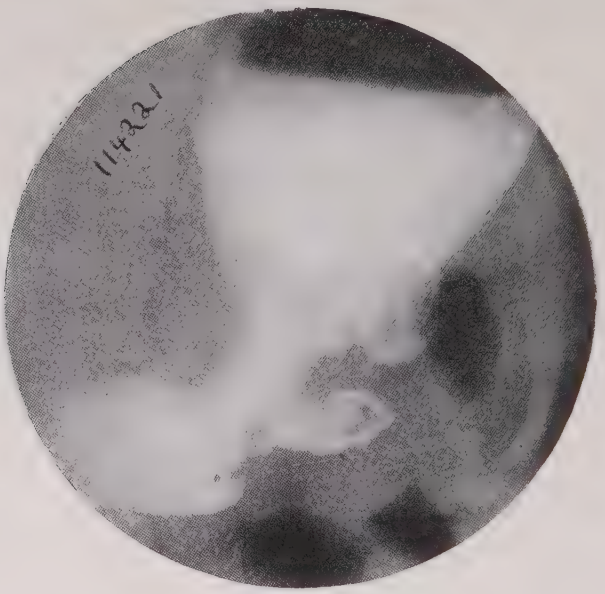

FIG. 89.—Extensive filling-defects, in the body of stomach, due to cancer at *a*

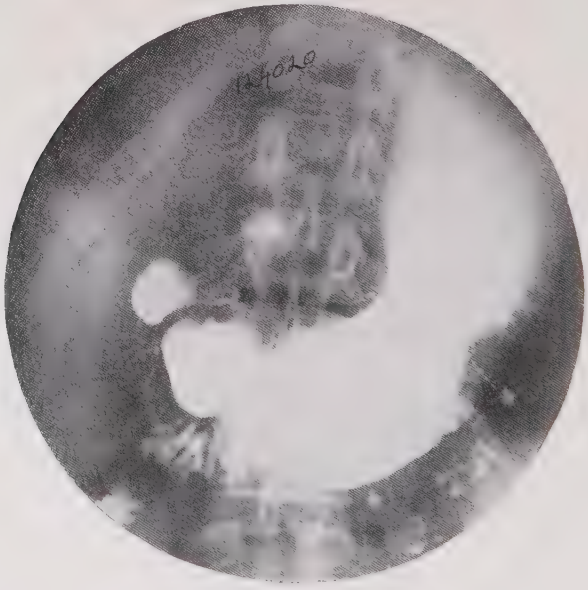

FIG. 90.—Apparent filling-defect along the greater curvature, due to gas in the colon at *a*.

FIG. 91.—Filling-defect in vertical portion of the stomach, produced by an extrinsic tumor, at *a*.

FIG. 92.—Apparent filling-defect, caused by pressure of stomach against the spine, seen at *a*.

(Fig. 92), is likely to be misinterpreted by the novice as an actual filling-defect. Tests of the genuineness of a filling-defect are its persistence under all conditions during the screen-examination, its unaltered position and configuration after massage, its constancy upon all plates and at successive examinations, and, as a differential point from spasm, its resistance to antispasmodics.

Fig. 93.—Penetrating ulcer at *a*. Incisura at *b*.

An *incisura*, often a relatively deep, narrow, finger-shaped, indentation, sometimes a small angular notch, almost always located on the greater curvature, is seen occasionally in ulcer, as a result of spastic contraction of the circular muscle-fibers in the plane of the ulcer (Fig. 93). Similar incisuræ may be produced by an adhesion-band, or by reflex spasm from conditions outside the stomach. The wide, relatively shallow, spastic indrawing of the curvature seen now and then opposite a carcinoma is sometimes spoken of as a wide incisura. The incisura of gastric ulcer occupies a constant position and is usually per-

sistent, although some observers have claimed that shallow ulcers or erosions may give rise to intermittent incisuræ. Two ulcers in different planes may cause a double incisura. The incisura arising from an extrinsic reflex is most often of an exaggerated type, being deeper and wider than the incisura of ulcer. Frequently it is associated with a tumultuous, irregular peristalsis, and travels like a peristaltic wave. Again, it may persist at one spot, or recur there intermittently.

Alterations of Tone.—The hypertonic stomach, though found in normal persons, is also a common accompaniment of non-obstructing duodenal ulcer, and it may result reflexly from other irritated foci outside the stomach (Fig. 94). The small shrunken stomach of scirrhous carcinoma or fibromatosis is only apparently hypertonic.

The hypotonic stomach is frequently observed without a lesion, especially in asthenic persons and those with relaxed abdominal walls (see "Normal Stomach, Tonus"). Loss of tone and dilatation of various degrees may occur as a sequence of long-continued spastic or organic obstruction at or near the pylorus from gastric ulcer, carcinoma, benign tumors, lesions of the gall-bladder, obstructive duodenal ulcer, etc. (Fig. 95).

Altered Position.—Since the cardiac end of the stomach is fixed and the pyloric end less so, we are concerned in most instances with displacement of the body of the stomach, more especially the lower pole, which may be dislocated in any direction. Displacement of the lower pole upward and to the left may be produced by perforated gastric ulcer, extrinsic tumors, ascites, pregnancy, heightened abdominal tension, hypertonus or spasm; downward in hypotonus, large tumors in the upper abdomen, dilatation or ptosis. Lateral displacement, to either side, by gas in the intestine or by tumors outside the stomach, is not uncommon.

Rarely the fundus itself may be displaced upward in diaphragmatic hernia or eventration, and Schlesinger[1] holds that it may participate to some extent in the downward displacement of gastroptosis.

FIG. 94.—Hypertonic stomach.

FIG. 95.—Hypotonic stomach.

The pylorus, tethered by the duodenojejunal ligament, is not easily susceptible to any great amount of dislocation in an individual case. But its position varies markedly in different individuals, in correspondence with the form of the stomach and the habitus (see "Normal Stomach"). Sometimes, also, its position is not in harmony with the general position of the stomach, and a degree of displacement may be obvious. Thus with the curled-up, snail-form of stomach, seen rarely in gastric ulcer, the pylorus may lie well to the left of the median line. Exceptionally, the pyloric end may be distorted and drawn upward and to the right by pericholecystic adhesions. While I have observed broad variations as to the height of the pylorus in persons without any gastric lesion, Groedel[2] considers pyloroptosis as a sign of gastroptosis, and with the ptosis is associated a greater mobility of the pylorus.

Occasionally there is noted an apparent torsion of the fish-hook stomach to the right side on its long axis, so that the corpus lies in front of the pylorus; this displacement seems most often to be produced by causes outside the stomach, and is without other import. Transposition of the stomach, as a feature of *situs inversus*, deserves only casual mention.

Alteration of Size.—Diminished size (capacity), real or apparent, may be due to hypertonus, increased intra-abdominal tension, carcinoma, syphilis, benign tumors, spasm, starvation, esophageal obstruction, operative resection, or gastro-enterostomy.

Increased size may be the result of hypotonus, functional atony, or dilatation consequent upon obstruction at or near the pylorus (gastric ulcer, carcinoma, benign growths, obstructive duodenal ulcer, adhesions from pericholecystitis, etc.). The elongated (ptosed) stomach shows an incidental increase of capacity. The functionally hypotonic or atonic stomach is expanded chiefly at its lower pole; the elongated stomach largely retains its tubular form; the dilated (ectatic) stomach is enlarged throughout, including its pyloric portion, which is not only expanded but also extends well to the right.

Altered Mobility.—It should here be repeated that lessened mobility is seen normally in high-seated and hypertonic stomachs, not only because they are situated unfavorably for manipulation, but also because they are short and more or less tensed between their chief suspension-points. Apparent diminution of mobility may result also from increased tension of the abdominal muscles. However, fixation of various degrees and at various points may ensue from perforated ulcer, carcinoma or any perigastric inflammation producing adhesions. Such fixation may be evidenced not only by the ineffectiveness of efforts at shifting by palpation, and changing the patient's position, but also by the failure of deep respiration to alter the position of the affected gastric area. In rare instances, bands of adhesions may produce irregularity of the gastric contour at the adherent point. Fixation of the pyloric end of the stomach as a result of inflammatory processes in the right upper abdominal quadrant due to pericholecystitis, perforated duodenal ulcer, etc., are not easily determined. Palpatory pressure sometimes merely dislocates the gastric contents and gives the impression that the gastric wall is moved also, although the latter may be adherent. On the other hand, an apparently fixed area may be found entirely free at operation. Excessive mobility of the lower pole is a common feature of hypotonic, atonic and ptosed stomachs.

Lessened Flexibility.—Loss of flexibility, as shown by a lack of response of the gastric wall to narrow palpation, may result from any infiltrative process, but is seen characteristically in extensive carcinoma and in the "leather-bottle stomach." Here the infiltrated, stiffened wall of the stomach glides away from the palpating finger, which in the normal stomach produces a correspondingly narrow indentation. This lack of pliability is also confirmed by the local or general restriction of expansion upon adding to the contents of the stomach. Somewhat similar stiffening, though usually of a lesser degree, may be seen in gastrospasm, but an intense spasm of the pars pylorica may temporarily constrict it to a narrow, rigid, palpable tube. In

judging flexibility, the examiner should take into account the accessibility of the stomach to palpation. A stomach situated high in the abdomen can be little affected by manipulation.

Gas-bubble.—Variations in the size of the gas-bubble have little or no pathologic significance. In aërophagy the bubble is often quite large, and may or may not diminish after the patient belches. Normally regular and symmetrical in outline, its contour may be broken by a tumor of the cardia, by splenic or hepatic tumors, by a gas-distended splenic flexure of the colon, or by herniation of the stomach through the diaphragm. Carcinoma, which is by far the most common intrinsic tumor involving the upper cardia, usually implicates the lesser-curvature side, and opaquely deforms this aspect of the gas-bubble. Gas in the splenic flexure is more likely to distort the outer aspect of the gas-bubble, and the haustrated, translucent colon is easily distinguished.

Secretion.—An excessive amount of secretion is sometimes discoverable by the roentgen examination. The upper level of the accumulated fluid may reach nearly or quite to the gas-bubble, and the barium, as it is swallowed, descends through it slowly. After the stomach is filled the translucent layer between the gas-bubble and the opaque ingesta is sometimes extraordinarily wide. Such hypersecretion, or retention of secretion, is more likely to be observed in any obstructive condition near the pylorus, but more particularly in gastric ulcer, or duodenal ulcer. It is frequently associated with a retention from the six-hour meal, and often with some degree of gastric dilatation. Absence or diminution of secretion may be also more or less evident in the achylia of carcinoma or after gastro-enterostomy.

Abnormal Peristalsis.—Gastric peristalsis is subject to considerable diversity as to the number of waves to be seen simultaneously, their energy (as shown by their depth), their frequency, regularity of succession and point of origin and termination. While these variations may occur in non-pathologic conditions, as mentioned in the discussion of the normal stomach, they often possess diagnostic significance, although, as Kaestle[3]

says, the line is not at present drawn sharply enough to make it always possible to say positively where the normal ceases and the abnormal begins.

Sluggish peristalsis, with diminution of the number and depth of the waves, may be consequent upon low acidity, hypotonus, fright or disgust. Kaestle[4] remarks "that in atonic ectasia the peristaltic waves are shallow and sluggish, and new-formation of the antrum is lacking." I have repeatedly observed this faintness of peristalsis in the so-called atonic stomach, but when a wave definitely formed it was nearly always possible to follow its progress to the pylorus.

While Cannon[5] admits the usual association of acid gastric content and peristalsis, he has observed deep and strong peristaltic waves in the stomach when the contents were strongly alkaline. The increase of peristaltic vigor by hyperacidity has often been noted as has also the tendency of hypertonus to be associated with well-marked peristalsis. From a diagnostic standpoint, therefore, neither moderately diminished nor moderately increased peristalsis has any import. There are peristaltic phenomena, however, which are definitely abnormal and which have strong diagnostic significance. These include absence of peristalsis, either general or local, hyperperistalsis, irregular peristalsis and antiperistalsis.

General absence of peristalsis may be due to extensive carcinoma, fibromatosis, syphilis or general gastrospasm. The complete inertia of the stomach is striking, although in non-obstructive cases there is usually also a continuous and copious drainage of the gastric contents through a gaping pylorus. In addition to the absence of peristaltic movement, the gastric contour is manifestly deformed by widespread filling-defects, and, if gastrospasm is eliminated, the presence of an intrinsic organic lesion is practically certain.

Absence of peristalsis from a local area may be caused by a new-growth, inflammatory infiltration, adhesions, or localized spasm involving that segment of the stomach. While the affected zone remains immobile, peristalsis may be noted in the

uninvolved musculature above or below, and this feature is often of service in detecting early or small organic lesions.

Hyperperistalsis, with an increase of the number (three or more) and depth of the waves on both curvatures, is seen typically in obstructing lesions of the duodenum (Fig. 96). Whereas, with the technic previously described, the stomach of the standing patient normally shows but one or two peristaltic

FIG. 96.—Hyperperistalsis.

constrictions, there are now seen three or more waves, rather equally indenting both curvatures and regularly succeeding each other. The appearance of hyperperistalsis is often delayed for several minutes after the stomach is filled, in which case it may succeed ordinary and average peristalsis. Periods of hyperperistalsis may alternate with less active periods. Hyperperistalsis may occur also with non-obstructing duodenal ulcer and as a reflex from other extrinsic irritations (disease of the gall-bladder or appendix, etc.) but, while the number of waves is increased, their depth is less exaggerated than in duodenal obstruction.

The hyperperistalsis accompanying organic obstruction at, or proximal to, the pylorus, as I have observed it, contrasts markedly with the hyperperistalsis of duodenal obstruction. The hyperperistalsis of pyloric and prepyloric obstruction is erratic in character. It affects the greater curvature chiefly, or at least more than the lesser curvature. The waves are often eccentric and disorderly; deep and shallow waves alternate with each other and often with irregular spacing between (Fig. 97). In this

Fig. 97.—Hyperperistalsis of the irregular type.

connection the remarks of Kaestle[6] are worthy of quotation. He says: "In pyloric stenosis there is found a deepened, vigorous peristalsis, beginning abnormally high in the stomach. The finding of stenotic peristalsis in an ectatic stomach justifies the diagnosis: 'Obstructive ectasia, not atonic.' With continued loss of muscular power in pyloric stenosis and obstructive ectasia, there remains, at least early after ingestion, visibly deepened peristalsis. Later on, one sees deep contractions of the gastric wall only in the first moments after taking the meal, often

only while the ingesta are flowing in. Finally, only by energetic massage does one obtain a contraction, deep, immovable, and remaining in one place, until this also no longer occurs and the mass of contents lies motionless on the floor of the stomach." Barclay[7] states: "A normal stomach that occasionally shows very powerful waves (or successions of waves) of peristalsis with periods of inactivity between, is suggestive that peristaltic action is becoming worn out, and if this sign is observed on one or two occasions it is practically certain that obstruction is present."

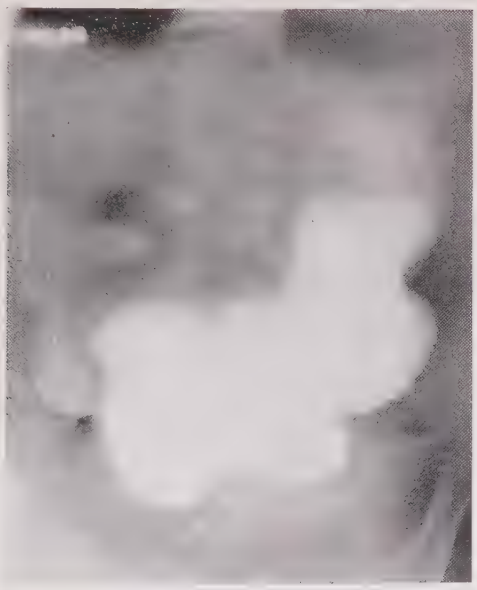

FIG. 98.—Antiperistalsis. All the waves here seen are moving from the pylorus toward the cardia.

Antiperistalsis, the first radiologic observations of which were published by Jonas,[8] consists in the passage of contraction waves in a reverse direction, *i.e.*, from the pylorus toward the cardia (Fig. 98). Haudek[9] states that the waves usually arise in the antrum pylori, may be followed along the greater curvature to the point separating the lower from the middle third, vary in their depth, and may alternate with normal peristaltic

waves. He considers it needless to say that the occurrence of vomiting has nothing to do with antiperistalsis of the stomach. He regards antiperistalsis as a sign of some organic alteration in the walls of the stomach or duodenum, and has noted it most frequently in pyloric stenosis, usually on a basis of carcinoma or ulcer, although it is not an invariable concomitant of stenosis. He mentions, without specific reference, the finding by Holzknecht and Robinsohn of antiperistalsis in the gastric crises of tabes, and the observation by Salomon of this phenomenon in neurasthenic persons.

In my experience antiperistalsis has been observed in a large number of cases. Without exception, obstruction was present or motility was interfered with by a lesion of the wall of the stomach, as indicated by a six-hour retention, and no case at operation failed to show an organic lesion. In most instances the lesion involved the pyloric ring or the prepyloric segment of the stomach, and was usually ulcer or carcinoma.

The exact points of origin of the antiperistaltic waves were not closely investigated, but for the most part they were first noticed in the vestibular region, and were seen on the greater curvature. Their rate of regression seemed to be about the same as the forward progress of peristalsis, and they disappeared in the pars media. Wider than normal waves, they are nearly always relatively shallow, sometimes so shallow that careful inspection is required to detect them, although in the illustration here shown (Fig. 98) the waves are well marked. Generally they appear to follow each other in fairly regular sequence, but run only for short periods. Haudek expresses the opinion that if there is a tendency to antiperistalsis the amplitude of the waves, and hence their visibility, can be increased by any stimulus which will increase the depth of ordinary peristalsis.

Disordered Motility.—Abnormal motility may be manifested either as an acceleration or retardation of the gastric clearance.

It is evident that the double-meal method does not concern itself with hypermotility in terms of exact time of evacuation, although this can be established with either the first or the

second meal if desired. As a rule, the degree of hypermotility can be reckoned by the advance of the head of the first meal beyond the cecum, plus the freedom and continuity of exit of the second meal through the pylorus. It is true that the position of the six-hour meal is the net result of the motility both of the stomach and intestine, but in the absence of intestinal obstruction as shown by other roentgen signs, or severe obstipation or diarrhea as indicated by the anamnesis, the intestinal factor can be disregarded.

In the presence of a decided hypermotility we should consider as possible causes duodenal ulcer, gastric carcinoma, anacidity and diarrhea. The report of the gastric analysis or the clinical history will decide as to anacidity or diarrhea, respectively. The most typical hypermotility is seen in cancer with gaping pylorus, which may be infiltrated and stiffened or merely relaxed by the anacidity. The flow through the pyloric opening is continuous and frequently voluminous, and the six-hour meal may have advanced into the transverse colon or beyond. The hypermotility of gastric cancer is not incompatible with actual narrowing of the pylorus, which remains steadily open and thus more than compensates for the narrowing. Over 90 per cent. of gastric cancers will reveal other roentgen evidence (filling-defects), so that hypermotility is by no means a principal sign. The hypermotility of duodenal ulcer is commonly attributed to interference with the pylorus-closing reflex as well as to hypertonus and hyperperistalsis. Here, again, these factors may balance or even overcompensate a slight organic or spasmodic stenosis at the site of the ulcer. In any event, most of the cases of duodenal ulcer will show hyperperistalsis or deformity of the bulb.

An initial rapid rate of clearance of the second barium meal through the pylorus is not alone a dependable sign of hypermotility; advancement of the six-hour meal in the colon should be present also. I have seen numerous cases of cholecystitis (with and without periduodenal adhesions), chronic appendicitis, hypochlorhydria from all causes, and general reflex gastrospasm,

in which the clearance was large and uninterrupted during five or ten minutes' examination, yet this clearance was probably not characteristic of the whole period of digestion, since the six-hour meal was not advanced beyond its average position. By the process of elimination, few cases of actual hypermotility remain unexplained, and on the whole, it is of less practical importance than its converse.

In many cases, although the stomach is empty at six hours, retarded evacuation is evinced by the motor meal lying proximal to the cecum, together, sometimes with scanty initial pyloric clearance of the second meal. For such retardation, with an emptying time greater than three hours but less than six hours, there is a host of possible causes, including depressive psychic states, weak peristalsis, hypotonus or so-called atony, high *Hubhöhe*, ptosis (all of which occur commonly in asthenic persons), hyperacidity, reflex spasm of the pylorus and slighter grades of stenosis, whether uncompensated or only partially compensated. In my experience organic stenosis causing delayed gastric evacuation, but within six hours, have not been frequent. Shortening the time limit to say five hours in order to detect such cases would probably result in greater error by including physiologic and functional delays.

The six-hour limit allows for delay resulting mainly from weakened active factors of motility—tonus and peristalsis. Delay beyond six hours as shown by a definite residue (Fig. 99) signifies, as a rule, some disturbance of the passive factor, namely, organic or spastic obstruction at or near the pylorus. It should be reiterated that this delay must be exhibited in a substantial and visible residue, not mere traces held in the gastric folds nor a collection in the lower pole so small that it can be seen only with difficulty. With a retention of one-fourth or more of the meal, there is probably either obstruction of an organic character or a serious lesion interfering reflexly with emptying. Among the causes of organic obstruction we have noted duodenal and pyloric ulcer with cicatricial contraction, hypertrophic pyloric stenosis, pedunculated benign tumors (polyposis)

pyloric cancer, syphilis of the stomach, carcinoma of the upper jejunum, and adhesion-bands from inflammatory processes in the right upper abdominal quadrant, usually pericholecystitis. Other causes of obstruction mentioned in the literature are foreign bodies (hair-balls, fruit-stones, etc.), kinking of the prolapsed stomach at its duodenal anchorage, adhesions from chronic appendicitis, and tumors outside the duodenum pressing on it, although I have not encountered a six-hour retention attributable to any of these, except possibly the last.

FIG. 99.—Six-hour residue. Retention of about half the motor meal.

Small residues down to an eighth or less of the motor meal may, of course, result from organic narrowing. A more common cause is spasm of the pylorus occurring reflexly from a lesion of the stomach itself, such as ulcer, or from an extrinsic pathologic focus, most often the gall-bladder or appendix, and also, but rarely, from more remote abdominal lesions. Holzknecht[10] has noted the possibility of a six-hour bismuth residue from pyloric spasm due to morphinism or a single administration of morphin at the time of examination. Pancoast,[11] in studying

the effect of moderate doses of some opium derivatives on the gastro-intestinal tract of man, found that in most cases there is more or less pyloric spasm, increased peristalsis and a decided prolongation of the emptying time.

In explaining the mechanism by which gastric retentions are produced in the absence of an organic stenosis, roentgenologists have frequently assigned "pylorospasm" as a cause. By the clinician, the term is limited to a spasmodic contraction of the pylorus accompanied by pain, vomiting, etc., occurring commonly as a symptom of extragastric conditions. Roentgenologically, the word has been used rather broadly, perhaps somewhat loosely, to cover an irritable, or hypertonic, or spastic pylorus, which relaxes less freely or less frequently than the normal pylorus, regardless of symptoms.

A pylorus which is not organically stenosed not infrequently remains closed continuously or for abnormally long periods during the roentgen examination of anatomically normal stomachs showing a six-hour retention, and whether the term "pylorospasm" is or is not strictly applicable, the condition cannot be ignored as a probable cause of gastric retention.

To differentiate retention due to pylorospasm from that produced by organic stenosis, Sahli[12] has made use of sinking and swimming capsules. The distance between the floating capsule and the heavier capsule lying at the bottom of the stomach gives an idea of the amount of fluid in the stomach. The evacuation-time of water may thus be shown; this is usually normal in pylorospasm but prolonged in stenosis. According to Holzknecht and Sgalitzer[13] the administration of papaverin hydrochloride shortens the emptying time in pylorospasm to normal, increases it in stenosis and has no effect on a combination of the two. It may be given in a dose of 0.048 to 0.066 gm., an hour before the ingestion of the meal for a second examination.

As has been previously stated the high *Hubhöhe*, that is, a long, steeply ascending pyloric arm, may be a cause of hypomotility. Of very similar character is the "water-trap stomach" of Satterlee and Le Wald,[14] in many cases of which,

with the technic used, six-hour residues were noted. In both of these conditions there is usually a degree of gastric atony. Cannon[15] holds that in the normal stomach, drainage by gravity is an unfortunate conception, that the food is in exact equilibrium and that muscular action is necessary to its progression. Haudek claims, on the other hand, that the existence of an impeding action of a high level of the outlet has been shown experimentally, the evacuation-time being shortened when the patient lies in the right lateral position and prolonged when the patient lies in the left lateral position.

Neilson and Lipsitz[16] have found from experiments on healthy young men that lying on the right side produces a more rapid evacuation of water than does any other position, and that lying on the back causes a quicker emptying than the upright posture. In the light of these statements it would appear that while gravity probably plays a minor rôle in gastric evacuation, as compared with other factors, it cannot be altogether disregarded. A high situation of the pyloric outlet, without an associated gastric atony, may or may not cause delay of evacuation, but I have not seen such delay beyond six hours with the barium motor meal. Nor have I noted a six-hour residue attributable simply to hyperacidity, atony, or intestinal stasis with or without "kinking of the duodenum." While the motility of the stomach in a given case is susceptible to some variation from time to time, I have seldom seen a six-hour retention which did not recur at a subsequent examination if a lesion was present. However, in the case of a residue without any other diagnostic indications, the test with the motor meal should be repeated before conclusions are drawn.

The interpretation of the results from the double-meal method may be either simple or complex as desired. The observer may be content with determining the presence or absence of a residue at the end of six hours. With the presence of such a residue he can be fairly certain of an organic lesion somewhere in the gastro-intestinal tract, and probably in the stomach or duodenum. Again, he may take cognizance also of hypermo-

tility or lesser degrees of hypomotility. Still again, he may consider the results in the light of all the discoverable factors pertaining to motility, including the gastric form, position, tonus, peristalsis, and acidity. Finally, he may combine and correlate his findings with other roentgenologic signs, the physical examination and the clinical history. By the construction of "symptom-complexes" in this manner Holzknecht[11] was enabled to make diagnoses which he could not make otherwise. Although some of his complexes can hardly be accepted implicitly, his general plan of weighing the roentgen signs in combination with each other and in conjunction with clinical data is well worth while and I have followed it to advantage. While this has been criticized as an "indirect" method in comparison with the "direct" method, I can only say that I have often been able to make diagnoses by means of indirect sign-complexes in instances in which the direct were ineffectual.

Gastric retention can be combined into various indicative complexes. A six-hour residue with a large stomach of normal contour, showing hyperperistalsis, means, more than ninety times out of a hundred, obstructive duodenal ulcer. Residue plus an apparently normal gastric outline, plus an irregular, vigorous peristalsis, chiefly on the greater curvature, usually signifies a lesion involving the pyloric end of the stomach. A residue with an achylia, but without gross alteration of the gastric contour, should suggest the probability of either a small obstructing pyloric carcinoma, or obstruction of the duodenum by pericholecystic adhesions; careful attention to the pyloric and duodenal contours will usually make the distinction. Residue with hyperacidity and no irregularity of the gastric or duodenal outline would indicate a stomach reflexly affected by some other abdominal condition, notably cholecystitis or appendicitis. The possibilities of the roentgenologic estimation of motility are by no means exhausted. The method described in detail deals with the evacuation of a carbohydrate meal only. I can freely endorse its convenience and trustworthiness in the diagnosis of the graver and usually surgical conditions. By a mixed meal

and extension of the time limit, by examination at short intervals, or by testing the motility of each individual for carbohydrates, proteins and fats separately, the diagnosis of slighter disturbances of motility, amenable to medical treatment, might be possible. However, with all the work of the experimental physiologists before us, no meal can be devised the normal emptying-time of which can be foretold with certainty, and any test must be proved by trial with abundant material.

ZONES OF MOTILITY BASED ON THE SIX-HOUR MOTOR MEAL

	Hour	
Zone of Hypermotility	0	
	1	Early emptying, pathologic. (Non-obstructing gastric carcinoma. Duodenal ulcer. Diarrheic conditions. Achylia gastrica.)
	2	Early emptying, physiologic. (Hypertonic, steer-horn stomach.)
	3	Early emptying, pathologic, but slight, or partially compensated. (Duodenal irritation. Duodenal ulcer with obstruction sufficient to prolong the evacuation-time to two hours in spite of associated hyperperistalsis, hypertonus and free pyloric patency.)
Zone of Normal Motility	4	Normal emptying. (A normal stomach functionating in a normal manner.) Disordered motility with abnormal but balanced factors. (Stenosing carcinoma with achylia; average emptying-time.) Delayed emptying, physiologic. (Hypotonic fish-hook stomach.)
	5	Delayed emptying, pathologic, but slight or partially compensated. (Slight stenosis. Stenosis with hyperperistalsis.)
Zone of Hypomotility	6	
	7	Delayed emptying, pathologic. Stenosis. (*a*) Organic. (Obstructing pyloric carcinoma. Pyloric ulcer. Obstructing duodenal ulcer. Periduodenal adhesions, etc.) (*b*) Spasmodic. (Reflex pylorospasm from ulcer well above the pylorus, cholecystitis, appendicitis, and remote abdominal lesions.)
	8	
	Etc.	

A diagrammatic representation of motility may assist to a clearer understanding. Taking as a basis a meal which leaves the normal stomach in an average time of say three hours, such as the bariumized carbohydrate meal, the gastric evacuation time may be divided as represented on a scale of hours into three periods or zones, viz.: (1) A zone of normal motility; (2) a zone of pathologic hypermotility, and (3) a zone of pathologic hypomotility.

1. The zone of normal motility must extend from an emptying-time somewhat less than three hours to an emptying-time considerably greater than three hours, since the three-hour point may be fixed only as an average on either side of which a variation may be due to purely physiologic causes. Within this zone it is necessary also, as a conservative measure, to include slighter tendencies to hypermotility or hypomotility from causes which, though pathologic, are not pronounced or are compensated wholly or in part. General knowledge justifies the assumption that such variation toward hypermotility is not wide, and for the purpose of this diagram, the two-hour point as the normal minimum is chosen. The variation toward hypomotility, however, is much wider; Haudek makes a generous allowance to the end of the sixth hour which will be accepted. The contents of this normal zone would then include:

(*a*) Normal motility. (Example: A normal stomach functionating in a normal manner.)

(*b*) Early emptying, physiologic. (Example: A hypertonic, steer-horn stomach.)

(*c*) Early emptying, pathologic, but partially compensated. (Example: Duodenal ulcer with obstruction sufficient to prolong the evacuation-time to two hours in spite of an associated hyperperistalsis, hypertonus and free pyloric patency.)

(*d*) Disordered motility with abnormal but balanced factors. (Example: Stenosing carcinoma with achylia, yet with a net emptying-time of three hours.)

(*e*) Delayed emptying, physiologic. (Example: A somewhat hypotonic fish-hook stomach.)

(*f*) Delayed emptying, pathologic, but partially compensated. (Example: Stenosis with hyperperistalsis, emptying being retarded, but within six hours.)

2. The zone of hypermotility, restricted to an emptying-time less than two hours, would include such frankly pathologic conditions as non-obstructing gastric carcinoma, duodenal ulcer and diarrheic conditions.

3. The zone of hypomotility, beyond six hours, would comprise the stenoses, both organic and spasmodic, as examples of which may be mentioned obstructing pyloric carcinoma or ulcer, markedly obstructing duodenal ulcer, and reflex pylorospasm from disease of the gall-bladder, or gastric ulcer remote from the pylorus.

As a matter of fact we know that these zones may overlap each other and that time alone will not delimit normal from abnormal motility. The diagram, while somewhat practical in a way, illustrates the time factor only, and as said before, a final opinion must rest on an analysis of all the factors. The roentgen method renders this analysis both possible and practicable, and herein lies its superiority to the test-meal and tube.

Comparison of the Results Obtained by the Roentgen-ray and the Stomach-tube.—Our own statistics indicate that the six-hour, bariumized, carbohydrate meal is a more sensitive test of gastric motility than the method used by the gastro-enterologist.* At the Mayo Clinic during the year 1914 a series of 950 patients who had been examined both by the roentgen-ray and the test-

* At 6 p.m. previous to the day of examination the patient takes a modified Riegel meal; that is to say, he is instructed to eat an ordinary meal which must include bread, meat and potatoes. An hour later he eats 20 raisins, the skins of which are easy to identify and tend to remain in the stomach somewhat longer than the usual food materials. The gastro-enterologist's examinations are begun the next day, about 8 a.m., and depending on the number of patients to be examined, the interval after the motor meal varies from fourteen to sixteen hours. The estimate of motility is based on the presence or absence of food-bits or raisin skins from this meal as shown by tubing at the morning examination. The gastro-enterologist's technic includes also the administration of a modified Ewald test-breakfast for the chemical examination, but with this we are not here concerned.

meal went to operation. (This, of course, does not include several hundred operated cases in which one or the other motor test was omitted.) Two hundred and twenty of these, 950 (23.1 per cent.) showed at the roentgen examination a gastric residue from the six-hour meal. One hundred and thirty-one (13.7 per cent.) had food remnants. In other words, the roentgen-ray showed approximately 70 per cent. more retentions than the clinical test-meal. The lesions found were: Disease of the appendix, 125 cases; disease of the gall-bladder, 311; gastric ulcer, 109; gastric cancer, 137; duodenal ulcer, 268. Table I (page 161) shows the incidence of retention in each of these conditions, as found by the roentgen-ray and stomach-tube, respectively. The preponderance of six-hour barium residues over food remnants from the clinical test-meal is noteworthy, being twice as great in gastric ulcer and lesions of the gall-bladder; almost twice as great in duodenal ulcer; and half again as large in gastric cancer. In the 125 cases with lesions of the appendix, a retention was noted by the roentgen-ray in only 1 case, and found in only 2 cases by the stomach-tube. In only 12 of 311 cases with lesions of the gall-bladder was retention noted either by the roentgen-ray or by tubing. The greater number (209, 90.4 per cent.) of the 220 patients showing a barium retention were found at operation to have cancer or ulcer of the stomach or ulcer of the duodenum.

In 16 cases representing all five conditions, the stomach-tube revealed food remnants, while no six-hour retention of barium was found by the roentgen-ray. On the other hand, 105 patients had roentgen residues but no food remnants.

In 8 of the cases tabulated under gastric ulcer a duodenal ulcer also was found. All of these patients showed a residue from the barium meal, and 6 of them had food remnants.

In addition to the cases tabulated in Table I residues were found by the roentgen-ray in one patient in each of the following conditions: Cancer of the pancreas, tumor of the ileum, cancer of the common duct, hydronephrosis, tumor about the head of the pancreas, tumor of the left kidney, subdiaphragmatic

abscess, and cancer of the ascending colon. In the four first conditions retention was noted also by the gastro-enterologist.

How can the discrepancy between the gastro-enterologist's results and my own be explained?

1. It would seem probable that the time elapsing between the ingestion of the meal given by the gastro-enterologist's and its withdrawal is too liberal, and that the stomach was empty in many instances in spite of an actual and pathologic hypomotility.

2. It is quite possible that the tube may have failed occasionally to bring up food remnants which were present. Harmer and Dodd,[17] by watching with the roentgen-ray the introduction of the tube, frequently noted that the tip impinged against the gastric wall well above its most dependent portion, and continued efforts to pass the tube simply caused it to curl and displace the tip further upward. In other instances it was found that by passing the usual length of tube in cases of ptosis, the tip might fail to reach the residuum. This, they believe, is a common error. The posture of the patient and the position the stomach occupies in the abdominal cavity affect the success of tubage. From their observations they regard it as

TABLE I.—INCIDENCE OF GASTRIC RETENTION IN 950 CASES

	Total Number	With Residue (X-ray)		With Food Remnants (Tube)		With Residue (X-ray) only		With Food Remnants (Tube) Only		With Both Residue (X-ray) and Food Remnants (Tube)		Number without Residue (X-ray) or Food Remnants (Tube)	No. with Residue (X-ray) or Food Remnants (Tube) or Both
		No.	%	No.	%	No.	%	No.	%	No.	%		
Lesions of the appendix	125	1	0.8	2	1.6	1	0.8	2	1.6	0	0.0	122	3
Lesions of the gall-bladder	311	10	3.2	5	1.6	7	2.2	2	0.6	3	0.9	299	12
Gastric ulcer	109	50	45.8	25	22.9	29	26.6	4	3.5	21	19.2	55	54
Gastric cancer	137	83	60.5	57	41.6	29	21.1	3	2.1	54	39.4	51	86
Duodenal ulcer	268	76	28.3	42	15.6	39	14.5	5	1.8	37	13.8	187	81
	950	220	23.1	131	13.7	105	11.0	16	1.6	115	12.1	714	236

"obvious that failure to recover gastric residuum with the unaided stomach-tube from a fasting stomach or after the ingestion of a test-meal cannot be accepted as conclusive evidence of the absence of gastric stasis." Rehfuss, Bergeim and Hawk[18] have employed a tube devised on the principle of the duodenal tube, with a slotted metal tip, which by its weight seeks the most dependent part of the stomach. In instances in which the passage of the ordinary tube failed to disclose any residue, the new tube obtained considerable amounts. The authors found, further, in a series of healthy persons, that the fluid residuum in the normal empty stomach far exceeded the accepted limit of 20 c.c., and in several was above 100 c.c.

3. The tube may have failed to reach food retained in the lower loculus of an hour-glass stomach. It seems probable that this occurred in at least one instance of hour-glass stomach in which the roentgen-ray showed a residue, but the gastro-enterologist reported none.

4. Marked differences as to the quantity and character of the food taken by the patient may have affected the gastro-enterologist's results.

5. In exceptional instances of organic stenosis at the pylorus (cancer or ulcer) the tube found retained raisin-skins when the roentgenologic test failed to show a barium retention. It is clear that a stenosis might be sufficiently narrow to block the passage of these skins and yet permit a fair exit of finely divided barium.

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CHAPTER VIII

GASTROSPASM

The roentgenologic diagnosis of disease in the digestive tract requires a thorough familiarity with spasm of the visceral musculature, its numerous manifestations and their relative significance. Though recognized early by roentgen workers and mentioned occasionally in the literature, spastic phenomena deserve increasing attention and study, because they are relatively common and occasionally very perplexing.

Organic deformity of the luminal contour is the principal direct roentgenologic sign of disease in the digestive tube. It is the mainstay of roentgen diagnosis, not only evidencing a lesion but directly revealing its seat, its extent and often its character. Conspicuous examples of organic deformity are seen in the filling-defect resulting from gastric cancer and the niche of chronic penetrating gastric ulcer, the diagnostic value of which must be conceded.

Many roentgenologists refuse to make a diagnosis in the absence of these signs, and claim that "sign-complexes" made up of indirect manifestations are of no value. This view is far too radical, for the fact remains that if roentgen diagnoses were limited to cases in which these direct indications are noted, many lesions of the alimentary canal would pass undiscovered. At present we are often obliged to rely for diagnosis upon more remote phenomena, such as alterations of motility, tonus and peristalsis. All of these can be materially affected by spasm. Further, we are also more or less dependent upon changes of contour, spastic in nature but set up by an intrinsic lesion, as, for example, the incisura and spasmodic hour-glass of gastric ulcer. Still further, and what is even more important, we encounter and must be able to recognize spastic deformity of outline produced

reflexly by extrinsic conditions remote from the deformed organ. Such deformity may deceptively simulate the distortion produced either directly or indirectly by an intrinsic lesion. Thus the roentgenologist is called upon to deal with two types of spasm. Probably identical in the mechanism of their production, namely, an irritant acting through a reflex arc, they nevertheless differ widely in significance. In the one instance the termini of the arc lie within the same organ; in the other, within different organs. One is most often a help to diagnosis; the other most often a hindrance. By a pardonable ellipsis we may speak of the one form of spasm as intrinsic; the other as extrinsic.

All divisions of the digestive tube are subject to spasm, and it is so frequently met with that it must be kept continually in mind by the examiner. Spasm of the esophagus has already been mentioned. Spasm of the small intestine and colon will be referred to in their respective chapters.

The favorite playground of spasm, whether of intrinsic or extrinsic origin, is the stomach. Spasm of the stomach, arising from an intrinsic lesion, is most generally produced by ulcer, less often by cancer.

Three forms of spasm due to gastric ulcer may be distinguished:

1. The incisura or hour-glass stomach.
2. Diffuse spastic distortion.
3. Spasm of the pyloric sphincter.

1. The incisura, the spastic indentation of the greater curvature in the plane of an ulcer, has been described previously. Usually narrow, but of variable depth, persistent and permanent as to situation, it suggests at once the nature of the lesion and points toward its site. The cavity of the ulcer itself may be seen often as a niche or pocket, but sometimes neither can be distinguished. In the latter event, the incisura either alone or in combination with other indirect signs may guide to the diagnosis which otherwise could not be made (Fig. 100).

When the incisura is deep the stomach is bilocular and may either be described as an hour-glass stomach, or the incisura only

FIG. 100.—Spastic incisura at *a*, opposite an ulcer on the posterior wall near the lesser curvature.

FIG. 101.—Spastic hour-glass at *a* accompanying perforated gastric ulcer, *b*.

may be given emphasis by the examiner. In other instances the width and depth of the constriction are so extreme that the characteristics of a typical incisura are lost, and a pronounced hour-glass form is seen (Fig. 101).

2. Gastric ulcer often gives rise to a regional spasm affecting a considerable extent of the pyloric segment, whether the ulcer is situated in this region or higher up in the stomach. The stomach, well outlined in its upper portion, shades off into a poorly

Fig. 102.—Diffuse spasm, pyloric portion of stomach at *a*, in association with a gastric ulcer, the crater of which can be seen at *b*.

filled, vaguely outlined, antral area, resembling the filling-defect of a pyloric cancer (Fig. 102). By manipulation the opaque ingesta can sometimes be forced into that part of the stomach, thus producing a normal outline, but when manipulation ceases the defect reappears. This regional spasm may be the sole roentgenologic sign of the ulcer.

3. An ulcer situated in the pyloric segment is rather frequently accompanied by a retention from the six-hour meal. Ulcers situated well away from the pylorus are also often

associated with a six-hour retention. This retention has been variously ascribed to reflex pylorospasm from the ulcer, to impairment of peristalsis by the ulcer and to pyloric spasticity excited by hyperacidity. Be this as it may, I have seen cases in which a retention from the six-hour meal was the only discoverable sign of the ulcer.

Cancer of the stomach, aside from the organic filling-defect produced by the tumor-mass, may produce also more or less

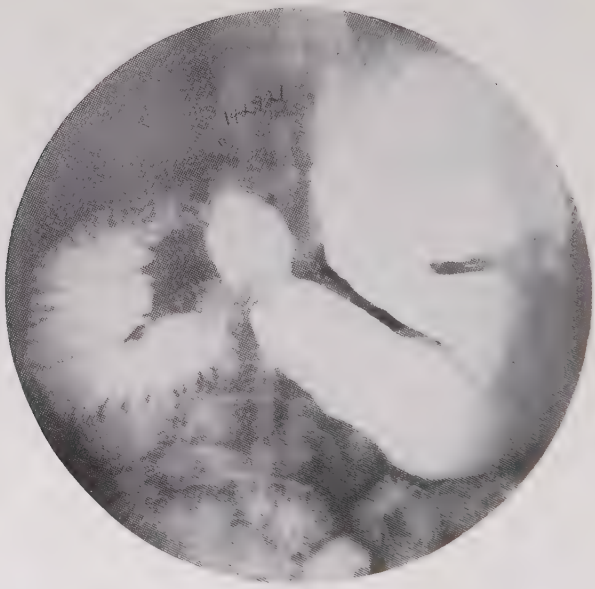

Fig. 103.—Spastic incisura at *a*; small mucoid cancer, posterior wall.

spastic distortion of the gastric contour. For example, a cancer involving only a portion of the lesser curvature may be accompanied by a spastic indrawing of the greater curvature opposite the lesion. When present, it is usually of considerable width and exaggerates the luminal narrowing produced by the tumor. The examiner is quite likely to regard the broad incisura as a part of the organic filling-defect, but generally the incisura is sharply sketched, while the filling-defect shades off gradually. The matter becomes of importance in forming an opinion as to the probable extent of the cancerous invasion. In rare instances a spas-

tic incisura may be the only definite roentgen manifestation of a small cancer (Fig. 103).

All of the foregoing spastic phenomena are intrinsic, that is to say, they originate from lesions of the stomach itself. The extrinsic spasms, those which accompany abnormal conditions outside the stomach, often remote from it, are less frequent.

Fig. 104.—Apparent filling defect, pyloric segment, at *a*. At operation disease of the gall-bladder was found but no lesion of the stomach.

One of these spasms takes the aspect of an incisura which is much like that of gastric ulcer but usually is either intermittent, or progresses toward the pylorus like a gigantic peristaltic wave. Occasionally a marked hour-glass form of the stomach which may either relax suddenly or persist throughout the entire period of examination, has an extrinsic cause, though it is difficult for the examiner to abandon his suspicion of the presence of a lesion

in the stomach. Intermittent and traveling incisuræ and transient hour-glass contraction of the stomach seem to occur more often in conjunction with duodenal ulcer than with any other morbid condition. Equally misleading is a spastic filling-defect, of extrinsic origin, occurring more commonly in the pyloric end of the stomach, and resembling a pyloric cancer or the diffuse spasm provoked by a gastric ulcer (Fig. 104).

In many instances after a barium meal is given none of it is seen to pass the pylorus for several minutes. The total and

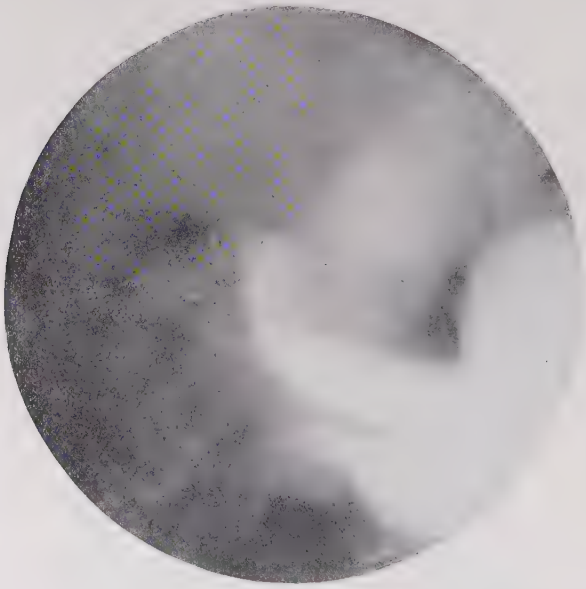

Fig. 105.—Spasm of the pyloric segment producing a spigot-like appearance.

free acidity are not unduly high, and there may or may not be a residue from the six-hour meal. At operation cholecystitis or chronic appendicitis is found, but no lesion of the stomach. In such cases there is evidently a pylorospasm, not necessarily in the clinical sense, but a spasticity of the pyloric sphincter, for which the only explanation that can be offered is the diseased gall-bladder or appendix. Sometimes the entire pyloric third of the stomach is shrunken to a stiff narrow tube which may be palpable to the examining fingers. The tube projects like a

spigot from the well-expanded fundus, and shows a striking likeness to the canal through a pyloric tumor. In this form of spasm disease of the gall-bladder is usually associated (Fig. 105).

The foregoing extrinsically caused spastic manifestations are all localized or regional, but spasm from an outside source may affect the entire gastric musculature, giving rise to what Holzknecht and Luger[1] have called "total gastrospasm." This may be characterized as a gastric hypertonus which far exceeds physiologic limits and renders the stomach contracted, tense and inert. The stomach is visibly diminished in size. The gas-bubble is small. Little secretion is present as a rule. Canalization is delayed, the first swallows of the meal being held high in the fundus. With continued filling the ingesta finally reach the pylorus, and the stomach assumes a fish-hook form but of diminutive size. It lies up under the left costal arch and entirely to the left of the spine. On further addition to the gastric content the fundus expands to accommodate it, but the pyloric portion remains narrow. Peristalsis is usually absent altogether, although there may be a few faint, irregular waves. The gastric contour lacks the smooth regularity of the normal filled stomach, being finely notched and broken here and there. Mobility and flexibility are not only actually lessened somewhat by the stiffened spastic gastric wall, but, by reason of the high sheltered position of the stomach, it often seems to be practically immobile and inflexible. The pyloric sphincter, on the other hand, may remain steadily open, and there is an early, free and continuous exit of the bariumized meal. The whole picture is much like that of an extensive gastric cancer and might easily deceive the unwary (Fig. 106). It should be reiterated that the frequent resemblance of reflected gastrospasm, whether local, regional or total, to the filling-defect of a cancer, makes it a source of danger, not only to the novice but to the expert as well. It follows that in the presence of what seems to be a filling-defect, precautions should always be taken to exclude the possibility of spasm.

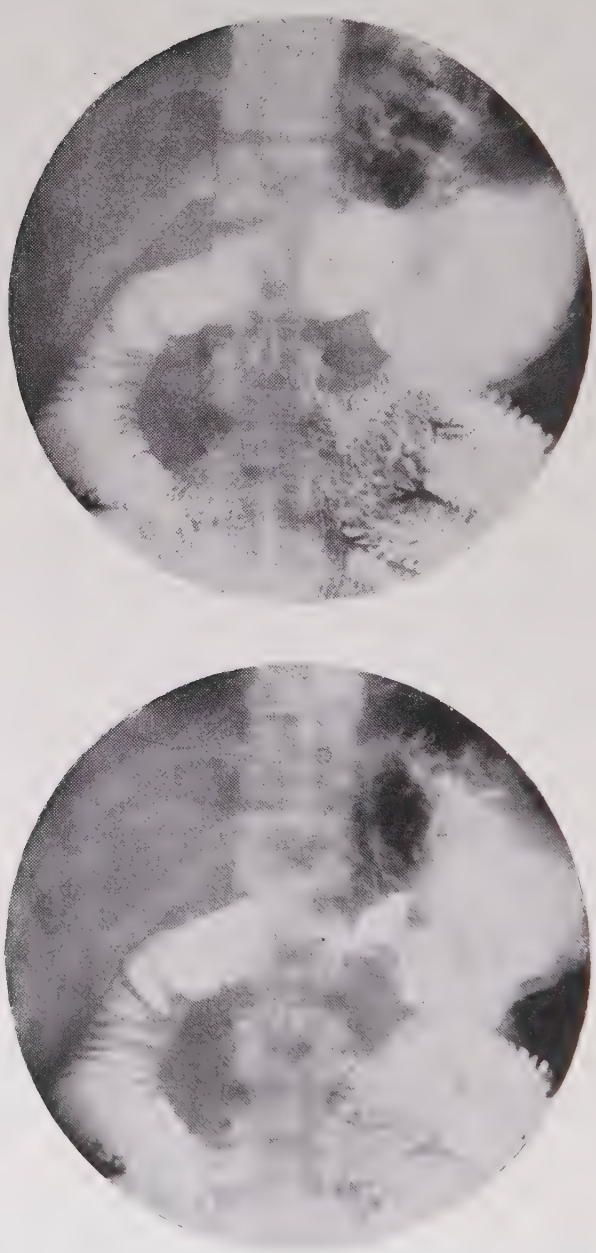

FIG. 106.—Total gastrospasm. Note marked irregularity of stomach and gaping pylorus. The two views, taken with only a brief interval between, show that the gastric deformity, though persistent, varies in aspect, thus distinguishing it from deformity due to an organic lesion.

To sum up, the manifestations of gastrospasm from an extrinsic reflex include the following:

1. Displacement of the stomach upward and to the left.
2. Diminution of gastric capacity.
3. Small size of the gas-bubble and small amount of secretion.
4. Tardy canalization.
5. Lessened mobility and flexibility of the stomach.
6. Disturbance of peristalsis:
   (*a*) Diminution.
   (*b*) Exaggeration.
7. Disturbance of the pyloric function:
   (*a*) Gaping of the pylorus.
   (*b*) Spastic contraction of the pylorus.
8. Incisura-production and hour-glass form of the stomach.
9. Deformity and pseudo filling-defects of the gastric contour, either local or general.

Etiology.—Admittedly the etiology of gastrospasm from causes outside the stomach is hardly susceptible of flawless proof. The association of duodenal ulcer, disease of the gall-bladder and appendix, hysteria and fright with gastrospasm is so frequent that the assumption of an etiologic relationship seems only rational. Other probable causes which have been noted include pancreatic disease, tabes, arteriosclerosis affecting the abdominal viscera, renal and ureteral calculi, uremia, and poisoning by lead, nicotin and morphin. Through the agency of the sympathetic nervous system to which it responds readily, the stomach obviously might be affected reflexly by these and many other disorders.

Differentiation.—Given a case which shows an irregularity of the gastric contour, the examiner must determine, as far as he can, whether the distortion is due:

1. To an organic lesion producing deformity directly at the seat of the lesion, or
2. To spasm set up by a lesion of the stomach, or

3. To spasm occasioned by or associated with abnormal conditions elsewhere than in the stomach.

This is best carried out by a process of exclusion, for while a parallel tabulation of the traits of these three conditions shows some discouraging similarities, there are, nevertheless, certain practical tests by which differentiation can be effected in most instances.

1. Deformity of the gastric outline produced by an organic lesion is persistent, constant in situation and unvarying in aspect. If due to a new-growth and accessible to manipulation, a palpable mass corresponding to the defect may sometimes be found. Its borders are sometimes sharp, but more often gradually shaded, and frequently the alternating elevations and depressions are seen as if in a stereoscopic view. It may be either painful or tender. The niche and accessory pocket of gastric ulcer are pathognomonic of themselves. Adhesions about the stomach are relatively rare, except those resulting from perforated gastric ulcer and disease of the gall-bladder, and they do not often deform the gastric contour.

If the gastric lumen near the pylorus is markedly encroached upon by an organic process, some degree of obstruction will be evident. The irregularity of contour is still seen at repeated examinations. It cannot be made to disappear by giving an antispasmodic.

2. Spasm resulting directly from an ulcer or cancer in the stomach is manifest usually in the segment involved, and especially in the area opposite the lesion. It tends to be constant in situation. As a rule, it is persistent and continuous, although it has been claimed that shallow erosions may cause intermittent spasm. The intensity of contraction may vary from time to time and thus alter its appearance. Its border is generally clear cut, but it may show as an indefinite zone of incomplete filling. The spastic area is not painful or tender, though there may be pain or tenderness localized to the causative lesion. The lesion provoking the spasm may be seen as a niche, accessory pocket or a neoplastic filling defect. The progress of the meal

may or may not be retarded, depending upon the extent of the lesion rather than upon the spasm, unless the pyloric ring is implicated. The spasm tends to persist at subsequent examination; it does not disappear after giving antispasmodics.

3. Indirect and remotely caused gastrospasm is often brief in duration or intermittent in appearance. It may be of the migratory type, traveling toward the pylorus like a peristaltic wave, or, though continually present in one situation, show a changing aspect from time to time. No tumor-mass corresponding to the defect can be felt ordinarily, and the exceptional spasm which produces a palpable stiffening of the gastric wall merely proves the rule. The borders of the spastic area usually are sharply delineated but if the spasm is shifting during the time of the exposure, the gastric contour may be hazily blurred in outline. The patient does not complain of pain at its seat, nor is it tender to pressure. Aside from marked pylorospasm, spasms of the gastric musculature do not give rise to any characteristic subjective symptoms. Unless spasm involves the pyloric sphincter, it tends to accelerate gastric motility rather than retard it.

Remotely reflected spasm is likely to be absent at a second examination. It invariably disappears after the administration of an antispasmodic to physiologic effect (Figs. 107 and 108).

Of course, it will be readily understood that these differential features are not absolute and inflexible, and the examiner may occasionally be foiled in a satisfactory analysis of his findings. At any rate, he ought not to omit any method that will eliminate indirect spasm from the field of consideration.

A prime quality of remotely reflected spasm is its instability, so that a second examination alone may suffice to exclude it. A practical test, upon which most roentgenologists rely for the exclusion of reflex spasm, is the administration of belladonna or its alkaloid. Irregularity of contour produced by a new-growth, and infiltration or adhesions of the gastric wall is of course, not altered by this drug. Likewise, the spasm arising directly from a lesion, such as the incisura of gastric ulcer, withstands its influence. Spasm reflected from a distant source vanishes.

FIG. 107.—Spasmodic hour-glass stomach from an extrinsic cause.

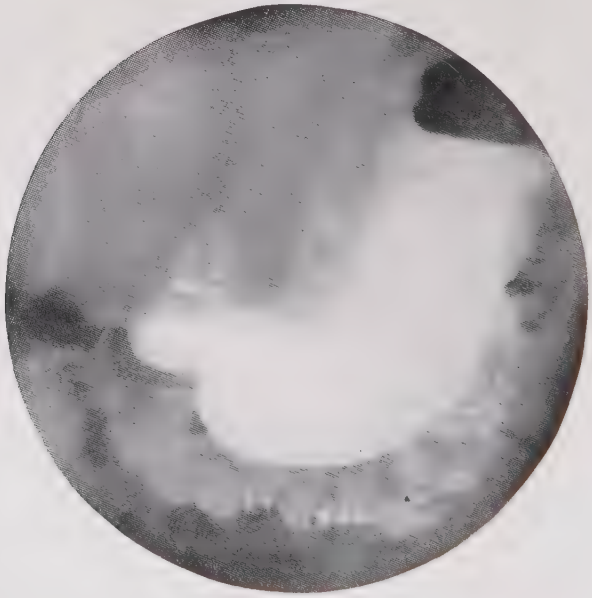

FIG. 108.—Same case as Fig. 107. Hour-glass effaced after giving belladonna.

The best results have been obtained by giving belladonna in the form of the tincture, starting with 1.33 c.c. t.i.d. and increasing and repeating the dose until the physiologic effect is obtained. The patient is then reëxamined. The essence of the test, however, does not depend on any arbitrary dose, but on obtaining the physiologic effects of the drug, as shown by dryness of the throat, flushing of the skin, dilatation of the pupils, etc. If the effects are not obtained the second examination will be inconclusive. Hence the patient should be seen once or twice daily and the dose increased, if necessary. On the other hand, the patient may have an idiosyncrasy for belladonna and this should be kept in mind. To save time, atropin sulphate in a dose of 0.0065 to 0.0130 gm. may be given hypodermatically and the second examination made a half-hour or an hour later. We do not use atropin hypodermatically because it is difficult to determine the dose necessary to produce a physiologic effect in a given case.

Spasm of any sort, whether intrinsic or extrinsic, disappears under general anesthesia. The spasmodic hour-glass stomach, due to an intrinsic cause and persisting after belladonna has been given to physiologic effect is not present at operation because it is relaxed by deep narcosis. Consequently, the surgeon finding no hour-glass on opening the abdomen may complain that the roentgen diagnosis is incorrect, and conclude that it is needless to look for any trouble in the stomach. However, a careful search will usually reveal a lesion, either in the stomach, or, exceptionally, in the duodenum.

In this connection it may be said that while belladonna usually relaxes gastrospasm arising from extrinsic causes, the incisura or hour-glass contraction of the stomach associated with duodenal ulcer appears to be an exception, for I have seen several instances in which this variety of spasm withstood the belladonna test.

The employment of papaverin and of Sahli's capsules to differentiate spastic retentions from those due to organic obstruction has been described in the discussion of disordered motility.

FIG. 109 —Hour-glass contraction at *a*, with distal narrowing.

FIG. 110.—Same case as Fig 109. Stomach of normal contour after giving an antispasmodic.

Case 112,360. Female, aged 39 years. For twenty-two years, at intervals of one to four years, the patient has had attacks of severe abdominal pain lasting for as long as one week. The attacks usually begin with weakness, loss of appetite and bloating, these symptoms being followed by the gradual development of pain at the right costal margin which radiates to the right shoulder-blade. At times the pain is so severe that morphin is required. There is no pyrosis or vomiting and no loss of weight. Some tenderness is noted in the right iliac fossa; none in the upper abdomen. Total acidity 32; free 16; combined 16. Roentgen examination: Prepyloric irregularity. Tendency toward hour-glass form (Fig. 109).

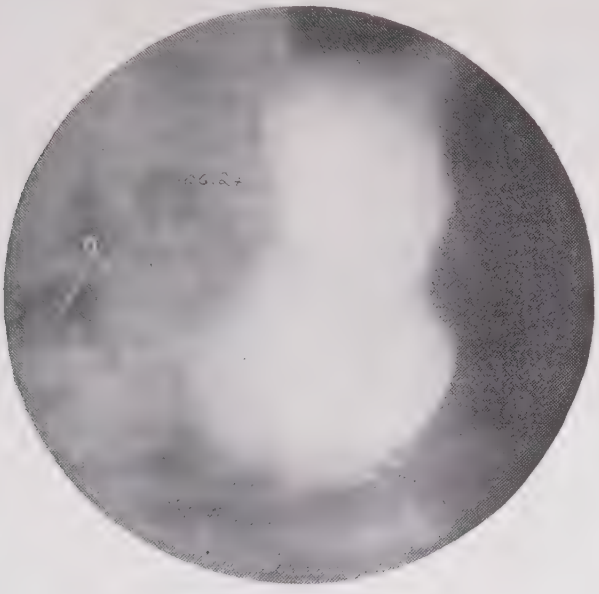

Fig. 111.—Obliteration of pyloric segment by spasm. Spastic area at *a*.

Second examination, four days later, after the administration of belladonna: Irregularity and hour-glass form absent. Stomach and duodenum negative (Fig. 110). The deformity of the stomach in this case therefore, was quite clearly due to reflected gastrospasm. Findings at operation: Chronic cholecystitis. One large stone. Appendix, negative. Stomach and duodenum, negative.

Case 117,798. Female, aged 66 years. In the past five years the patient has had many attacks of hard grinding pain in the right abdomen, radiating downward, and which comes on suddenly and lasts up to twelve hours. This pain is accompanied by much gas and bloating.

For four years soon after meals she has had daily distress in the stomach, with sour vomiting. Former weight was 130 pounds; present weight 105 pounds. Total acidity 24; free, 16; combined 8. Roentgen examination: Retention of half the six-hour meal. Prepyloric narrowing and irregularity (Fig. 104).

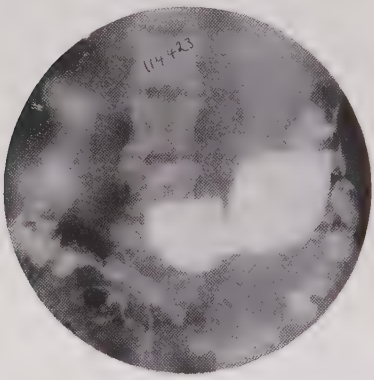

Fig. 112.—Localized spasm of greater curvature.

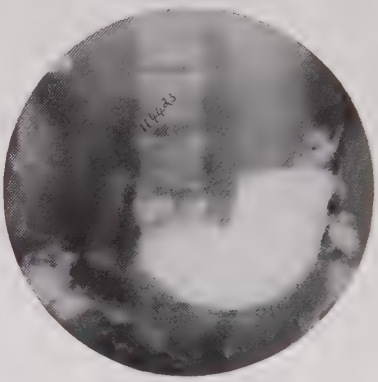

Fig. 113.—Same case as in Fig. 112. Spasm absent at second examination.

Fig. 114.—Spastic irregularity, pyloric end. Stomach normal at operation.

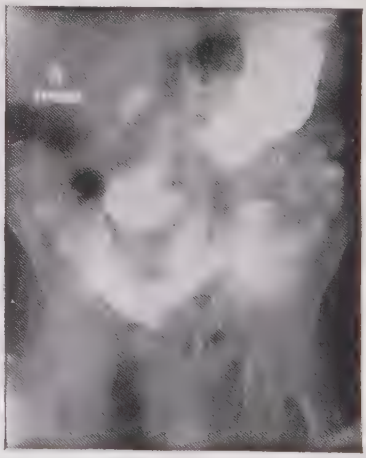

Fig. 115.—Marked spasm of stomach, pyloric portion. Operation; stomach normal; cancer of sigmoid.

Without giving belladonna, a second examination was made and the prepyloric irregularity was found still present. This was believed to be due to a prepyloric lesion. As the sequel shows, the case illustrates (1) the deforming effect of reflected spasm, and (2) the necessity

of giving an antispasmodic before reëxamining. Findings at operation: Cholecystitis with multiple papillomas of the gall-bladder. Chronic appendicitis. Normal stomach and duodenum.

Case 106,124. Male, aged 70 years. The patient has had intermittent diarrhea for six months and in the early part of this period had several attacks of vomiting, each attack lasting a day. He is on a rigid diet consisting chiefly of beef tea and toast. When this is not adhered to, he occasionally has epigastric pain. At times there is pain in the lower abdomen. Weight loss, 40 pounds. Marked weakness. Total acidity 14; free, 0; combined 14. Roentgen examination: No retention from the six-hour meal. Pars pylorica practically obliterated; the pars media ending in an irregular stump. Diagnosis: Cancer (Fig. 111).

The tentative clinical diagnosis was disease of the gall-bladder, but in view of the pronounced roentgen findings the final diagnosis was cancer. Findings at operation: Large septic gall-bladder, containing 240 c.c. of bile and a number of stones. Marked thickening of pyloric ring due to spasm.

In this instance the roentgen examiner should have suspected spasm for the following reasons: An organic lesion of the size indicated in the roentgenogram should have produced a six-hour retention and a degree of gastrectasia. Neither of these conditions was present. Further, a carcinomatous growth of this extent and in this situation would undoubtedly have been palpable and in this case none was felt. Thus there were at least three very good reasons for a reëxamination after the administration of belladonna.

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CHAPTER IX

GASTRIC CANCER

In the detection of cancer of the stomach, the roentgen-ray takes precedence over all other methods, despite the fact that "we are only in the daguerreotype stage of roentgen photography."[1] In the Mayo Clinic, 95 per cent. of gastric cancers have given distinct roentgenologic signs of their presence, a percentage not approached by any other process of examination.

Since nearly one-third of all cancers occur in the stomach, and since early recognition and operation alone afford a chance of cure, any measure which will increase the number of correct and early diagnoses is of the highest importance.

Prior to the development of gastric roentgenology, reliance for diagnosis had to be placed upon the history, the physical examination and the gastric analysis. Significant in the history were: middle or advanced age of the patient; digestive disturbance, such as anorexia, vomiting, occasionally pain, hematemesis, anemia, cachexia and loss of weight. By the physical examination search was made for the presence of a tumor. The gastric analysis was scanned for achlorhydria, food remnants, blood, and Oppler-Boas' bacilli.

It is quite clear that the most important of these evidences can result only from a cancer that is well advanced or obstructive. The records of our clinic show that in a large series of cases confirmed by operation, 67 per cent. of the patients had palpable tumors and 53.3 per cent. had food remnants. In other words, 33 per cent. had no palpable tumors and 46.7 per cent. had no food remnants to indicate obstruction. It is precisely in such cases as these that the roentgen-rays have their greatest field of usefulness. Indeed it is no longer necessary to

wait until a clinical diagnosis can be made on the presence of a palpable tumor and obstruction.

There is no intent to say that the clinical data should be discarded. On the contrary, the roentgenologist should be acquainted with the clinical facts in every instance. If suggestive of cancer, they will stimulate him to a more exhaustive search. If negative, they will exercise a wholesome restraint upon his interpretation of the reflex phenomena so often produced by conditions outside the stomach. More important still, the final diagnosis should be compatible with all the findings, if possible, and occasionally only their correlation will make the diagnosis. A combination of all methods forms a net through which few cancers will escape.

It must be conceded that the carcinomatous character of tissue can be determined positively only by the microscope; the roentgen-rays can show merely the presence of a gastric tumor, which may or may not be malignant. However, benign gastric neoplasms are uncommon; according to Graham,[2] 95 per cent. of tumors of the stomach are cancerous. Furthermore, practically all lesions encroaching on the gastric lumen are cancerous. In the occasional instance of a non-malignant new-growth, if the salient features of the clinical history are considered, the diagnostician will be at least suspicious of the fact. Seventy per cent. of all gastric cancers occur in the pyloric end of the stomach while 90 per cent. of all gastric ulcers occur on the lesser curvature and on the posterior wall near the lesser curvature above the incisura angularis. These statistics are based on surgical findings. X-ray findings are practically identical. These facts should be borne in mind when differentiating gastric cancer and gastric ulcer.

The roentgenologic manifestations of gastric cancer include departures from the normal contour, pyloric action, peristalsis, motility, flexibility, mobility, position, and size of the stomach. Enumerated in the order of their relative importance, these signs are:

1. Filling-defects.
2. Alterations of pyloric function:
   (*a*) Gaping of the pylorus.
   (*b*) Obstruction of the pylorus.
3. Perversion of peristalsis:
   (*a*) Absence of peristalsis from involved areas.
   (*b*) Weak peristalsis.
   (*c*) Antiperistalsis.
   (*d*) Exaggerated peristalsis.
   (*e*) Irregular peristalsis.
4. Altered motility:
   (*a*) Rapid and early emptying (non-obstructive cases).
   (*b*) Delayed emptying (obstructive cases).
5. Lessened flexibility.
6. Lessened mobility.
7. Alteration of size (capacity):
   (*a*) Shrinking.
   (*b*) Dilatation.
8. Persistent local spasm.
9. Displacement.

Filling-defects.—The filling-defect is the basic roentgenologic sign of cancer and practically indispensable to a positive diagnosis. It is occasioned by the projection of the tumor into the barium-filled lumen of the stomach, thus producing irregularity of contour. At the stage at which most patients first come for examination, the tumor has usually attained considerable size, and the filling-defect is sufficiently extensive to be readily seen.

In aspect, filling-defects vary somewhat according to the character and seat of the neoplasm. The fungoid cancer often reveals multiple gross irregularities, gradually shading off into the barium shadow and showing the elevations and depressions in perspective.

The infiltrating scirrhous cancer may narrow greatly (though

somewhat regularly) the lumen of the affected portion, which is most commonly the pyloric end.

A small cancer encircling the pylorus may produce a broadening of the duodenopyloric sulcus or a conical vestibule (Fig. 116). A more extensive cancer may seemingly cut off the entire pyloric segment (Figs. 117 and 118).

High in the pars cardiaca the tumor may infringe on the contour of the gas-bubble and contrast with the translucency of the latter. If the esophageal opening is involved, obstruction

Fig. 116.—Small encircling cancer at the pylorus. Filling-defect at *a*.

may be noted, with regurgitation of the meal and dilatation of the esophagus.

A tumor on the anterior or posterior wall alters the contour in the oblique or sagittal view; in the anteroposterior view it may show centrally as a less dense area within the barium shadow (Fig. 119).

The actuality and permanence of filling-defects cannot be determined with finality by a few roentgenograms alone. Essential here is the screen-examination, during which the gastric shadow can be studied at various angles by turning the patient,

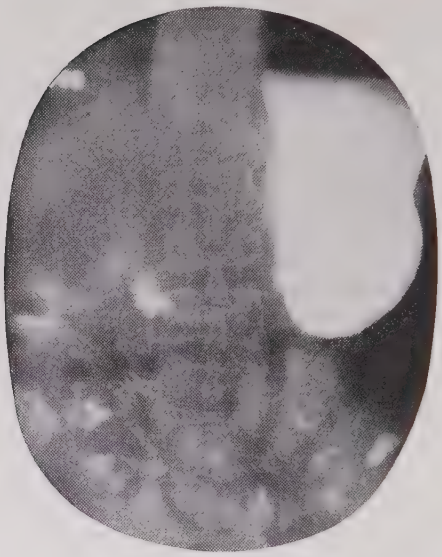

FIG. 117.—Cancer involving entire pyloric segment.

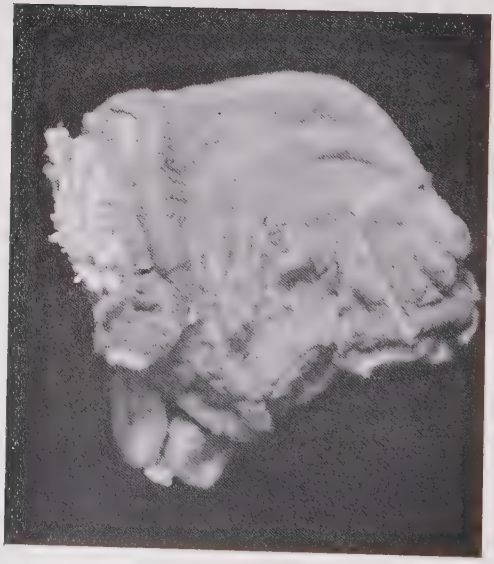

FIG. 118.—Same case as in Fig. 117. Photograph of specimen after resection.

and observation can be made of the effect of active and passive movements.

A true filling-defect is permanent; it shows no change in location or appearance after palpatory manipulation, after administration of antispasmodics, or on reëxamination.

Absence of peristalsis from the suspected area is strongly confirmatory.

The correspondence of a filling-defect to a palpable mass is

Fig. 119.—Central filling-defect, *a*, caused by a rounded cancer-mass projecting into the gastric lumen.

indicative of its genuineness. Tumor-masses that elude detection at the physical examination are sometimes felt by the roentgenologist. Descent of the mass into a region where it may be palpated is favored by the upright posture, and the shadowed gastric outline enables the examiner to palpate a specific area with greater exactness.

Unevenness of outline and lack of symmetry are rather constant in true filling-defects.

Filling-defects in the pars media or pars pylorica (Fig. 120)

are less likely to be overlooked than those in the pars cardiaca. A filling-defect well up in the fundus may be brought into better relief by pressing the barium upward, or by screening and plating with the patient in the recumbent position (Fig. 121). With the patient standing, small filling-defects in the pars pylorica also require careful study for detection, owing to the difficulty of obtaining a clear outline of this region because of its proximity to

FIG. 120.—Filling-defects in pyloric and mid-portions of stomach.

the spine, and the tendency of the barium to settle away from the pylorus of a fish-hook stomach (Fig. 122). A small defect, clearly seen in the partly filled stomach, may be concealed in the distended stomach. Hence, observation should be made during the process of ingestion as well as after repletion. The tube-box diaphragm should be actively employed while screening and the aperture narrowed to increase the distinctness of small suspected areas, thus facilitating close scrutiny.

Filling-defects situated in the pars media occasionally produce irregular hour-glass deformity (Fig. 123). Occasionally such an hour-glass is of the x-type in contradistinction to the

FIG. 121.—Cancer in upper cardia. Filling-defect at *a*.

FIG. 122.—Exclusion of barium from prepyloric region, *a*, by small obstructing cancer.

usual B-type of gastric ulcer or spasm, though this distinction is not invariable. As a rule, the hour-glass of cancer lacks the sharp definition of the hour-glass of ulcer or spasm, and shows an indefinite shading off.

Fig. 123.—Hour-glass stomach due to cancer. Constriction and irregularity of contour at *a*.

Filling-defects from Causes Other Than Cancer.—Filling-defects, either apparent or real, may be produced by numerous conditions other than cancer. Apparent filling-defects may result from the use of faulty media; secretion in the stomach; food remnants; hair-ball; gas or fecal matter in the colon; barium in the bowel adjacent to the stomach; lordosis and scoliosis; pressure of the stomach against the spine; pressure of a deformed costal arch; strong retraction of the upper abdominal wall; spasm; adhesions from perigastric inflammation; extrinsic tumors; displacement and distortion of the stomach by ascites, ovarian cysts or pregnancy. Actual filling-defects, not distinguishable of themselves from those of cancer, may be caused by various benign tumor-producing lesions of the stomach.

Faulty media in which the barium is unevenly distributed

may give varying degrees of opacity in the gastric shadow and thus imitate filling-defects. The mixture may be too stiff, poorly mixed, or an insufficient quantity of barium may be used. With very thin mixtures the barium often settles to the lower pole, leaving the upper gastric lumen unvisualized. A little palpatory shifting of the gastric contents readily shows the character of these pseudo-defects, and erroneous interpretation is not likely to occur unless an attempt is made to base a diagnosis upon plates alone.

Sometimes secretion is imprisoned in the pyloric end of a fish-hook stomach, showing as a clear area above the opaque meal. The straight horizontal line of demarcation between the secretion and the barium is indicative of the artificial nature of the defect. By palpatory pressure the secretion may be displaced by the meal, or passed into the duodenum.

Food masses in the stomach, by excluding the barium from the area in which they lie, may simulate filling-defects. Here palpatory shifting of the gastric contents will cause the seeming defect to change its situation or disappear. However, as a matter of routine, patients should be examined only in the fasting condition. Employment of the tube to withdraw food remnants in cases of pyloric stenosis should be resorted to unless otherwise contra-indicated.

Occasionally a hair-ball is found in the stomach of a neurotic person who is addicted to biting the hair. The accumulation may be a rounded ball, or may form a complete cast of the gastric cavity. In either event, after giving the bariumized meal the peripheral gastric contour will be shown fairly well. If the hair-ball is small it will show as a central area of diminished density somewhat like the filling-defect produced by a cancer on the anterior or posterior wall. The ball may be shifted about by palpation or even displaced upward into the gas-bubble. If the entire stomach is filled by the hair-mass, the gastric shadow will show peculiar streaking and mottling throughout.

Gas in the colon is a source of annoyance. Even after preparation of the patient by purging there is usually more or less

gas in the splenic flexure. Frequently the distention is sufficient to infringe upon the greater curvature and produce considerable deformity. Such irregularities ought not to be very deceptive, as they change with manipulation, and the distention of the transparent haustrated loop of intestine is rather obvious (Fig. 124). Rarely, the transverse colon may be displaced upward and lie directly across the stomach. Its course may be traced

Fig. 124.—Gas in colon causing pseudo-filling-defect at *a*.

by its transparency and haustration. Fecal matter in the bowel also may cause indentations in the adjacent gastric contour.

Deformities of the dorsal and lumbar spine, including lordosis and scoliosis, which may deform the contiguous gastric contour, are rather manifest and rare.

Pressure of the stomach against the spine, either normal or with well-marked physiologic lordosis, often disfigures the transspinal portion of the stomach. This disfigurement is seen often on plates made with the patient's abdomen pressed tightly

against the cassette (Figs. 125 and 126). Not rarely it is observed also during roentgenoscopy, especially when the patient maintains a high degree of abdominal rigidity and tension. These pseudo-defects can be avoided by encouraging the patient to relax his abdomen during the screen-examination, and by supporting the hips and shoulders when making plates in the prone position.

Fig. 125.—Deforming effect of pressure against the spine. The rugæ of the stomach can be seen in the distorted area.

Strong retraction of the belly-wall sometimes occasions a wide, regularly curved depression in the greater curvature of the stomach just below the left costal arch. Its smooth, sharp outline and its situation should differentiate it from an actual filling-defect (Fig. 127).

Spasm of the gastric musculature may produce very deceptive imitations of the filling-defects caused by cancer. Migrating or intermittent spastic contractions which are seen frequently, are evidently spasmodic because of their changing situation or interruption; but spasm is not always migratory or intermittent. Often a non-moving, spastic incisura will indent

FIG. 126.—Gross deformity of mid portion of stomach due to pressure against the spine.

FIG. 127.—Incurvation of the greater curvature at the left costal arch. This is often seen in thin persons with tense abdominal walls.

the stomach so as to form an hour-glass, exactly simulating an organic hour-glass stomach. In other cases the entire pyloric portion of the stomach may be constricted to a stiff, narrow tube, rolling under the palpating fingers as a cylindric mass. Again, the entire stomach may be spastically contracted, small, and uneven, without definite peristalsis. In all the above conditions the outline of the stomach, though not regular, is sharply defined, and this circumstance should put the observer on guard. However, there is still another variety of spasm which is dangerously misleading; in this form the barium shadow in the spastic area, which may be large or small, fades off toward the gastric periphery, exactly as though intruded upon by a tumor-mass. The spasm may sometimes be effaced by massage during the screen-examination, but as a rule it reappears. If accessible to palpation, the absence of a tumor from the suspected region should suggest cautious interpretation. The pyloric portion of the stomach is a common seat of this spastic deformity.

The points of difference between true filling-defects and those produced by spasm may be summed up as follows:

The true defect is permanent, often corresponds to a palpable mass if accessible, and is not often sharply delineated.

The spastic filling-defect is often migratory or transient and is frequently sharp in outline; the contracted muscle is rarely palpable. Spasm may disappear upon distracting the attention of the nervous patient thereby causing him to relax his abdomen, or by vigorous palpatory manipulation. Also, it may disappear or change its situation at a second examination. In many cases reëxamination after the administration of an antispasmodic is necessary. Belladonna, atropin, and papaverin are the drugs employed most generally (see Gastrospasm). Physiologic effects from the drug must be obtained, and large doses may be necessary. This procedure should never be omitted in any case in which the possible existence of spasm cannot absolutely be eliminated. In rare instances spasm may persist in spite of this measure, but such cases are quite uncommon.

Rarely, adhesions from perigastric inflammations may pro-

duce distortions resembling the filling-defects of cancer. The inflammatory process originates most commonly from perforated gastric ulcer or from pericholecystitis. A perforated gastric ulcer in the pars media, producing perigastric adhesions, is likely to reveal its identity by a pocket, a niche, or an incisura. Perforated ulcer in the pars pylorica may be less characteristic and fairly difficult to distinguish from cancer.

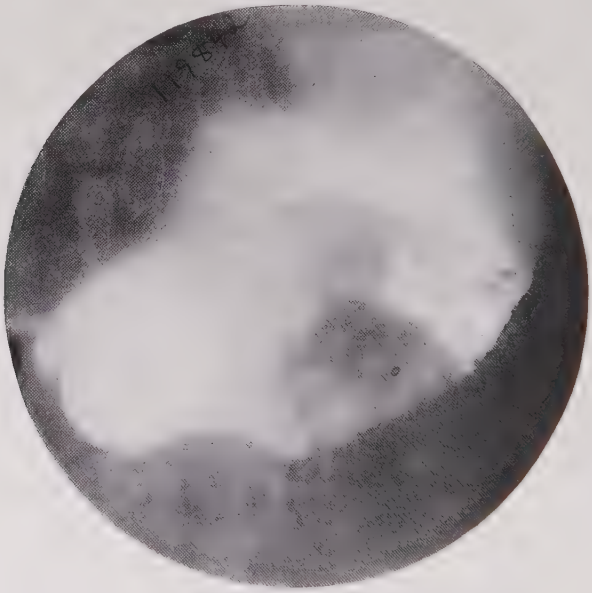

Fig. 128.—Gastric contour deformed by an extrinsic tumor—pancreatic cyst.

Tumors extrinsic to the stomach that deform its contour may originate in the liver, spleen, pancreas, kidney, large or small bowel, omentum, mesentery, or belly-wall. As a rule, the filling-defect occasioned by the thrust of the tumor into the gastric lumen is smoothly rounded, the inequalities being covered by the wall of the stomach (Fig. 128). Unless these tumors are adherent to the stomach, which is not usual, changes of position of the stomach with respiration or by palpation will alter the location of the filling-defect. In such cases also the peristalsis is usually normal or slightly increased, and this fact contra-indicates a tumor of the stomach itself.

The stomach may be eccentrically distorted and displaced by ascites, ovarian cysts, and other large abdominal tumors, pregnancy, or even by a tensely retracted abdominal wall. Such conditions should be rather patent.

Sarcoma, tumor masses produced by syphilis and benign neoplasms, as well as varicosities of the gastric veins, may cause filling-defects practically identical with cancer. These conditions are so unusual that the roentgenologist should not be unduly alert for them. If syphilis is suspected, the Wassermann test should be applied.

Alteration of Pyloric Function.—In cancer the pyloric function may be perverted in either one of two quite opposite ways, namely, either by gaping or by obstruction. The barium water often flows through a normal pylorus, with little or no interruption, but as soon as a thicker meal is given the flow usually becomes less free and intermittent. The gaping pylorus of cancer is characterized by a free and continuous exit of the meal from the stomach into the intestine. Very often the stream is voluminous and the upper small bowel is speedily filled with the opaque mixture (Fig. 129). The stomach may be almost or even completely emptied during the brief period of examination.

Gaping of the pylorus results from an interference with its sphincteric contraction, either by infiltration and stiffening of the muscular ring or by an absence of the pylorus-closing reflex. Thus it is seen quite typically in scirrhous cancer involving the pars pylorica, but is found also in association with cancers of the cardia or media, either scirrhous or medullary. A free and continuous flow somewhat similar to that seen with the gaping pylorus of cancer may be found in other conditions, such as duodenal ulcer, gall-bladder disease (with or without adhesions), achylia, certain diarrheas, and sometimes even in chronic appendicitis. It should be said, however, that in these conditions the flow as a rule is less voluminous than that noted typically in cancer.

FIG. 129.—Gaping pylorus in a case of gastric cancer. Note quantity of barium in duodenum and upper small bowel. This stomach emptied itself of the opaque meal in a very few minutes. The filling-defect of the cancer is seen in the cardiac portion of the stomach.

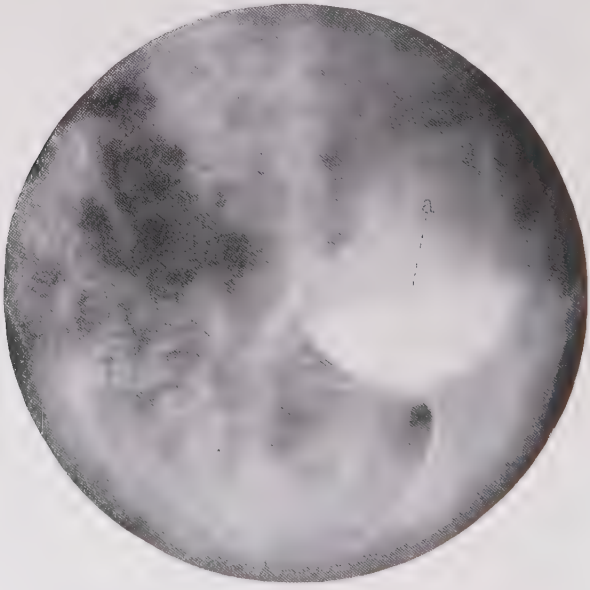

FIG. 130.—Six-hour retention, *a*, in a case of pyloric cancer.

Pyloric obstruction, as evidenced by a six-hour residue in the stomach, occurs in about 60 per cent. of gastric cancers—

Fig. 131.—Same case as in Fig. 130; stomach filled. Prepyloric filling-defect at *a*.

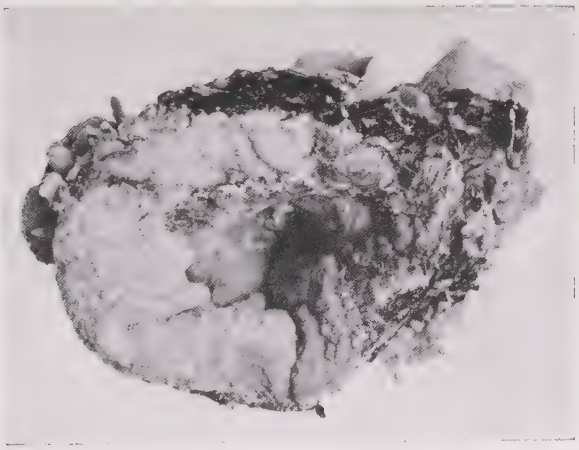

Fig. 132.—Photograph of resected specimen from case shown in Fig. 131.

oftener than with any other lesion. The amount of residue varies with the degree of obstruction (Figs. 130, 131 and 132).

It is noteworthy that the lumen of the pyloric canal may be considerably diminished by the intrusion of a cancer without resulting in a six-hour residue, for the reason that the lessened caliber is compensated by the lack of sphincteric control. Since numerous causes other than cancer may operate to produce a six-hour gastric retention, the presence of a residue should not be given undue weight in making the final diagnosis, but its occurrence should stimulate a careful search for filling-defects and other evidences of cancer.

Peristalsis.—The perversions of peristalsis resulting from gastric cancer are varied. Absence of peristalsis from a cancerous area of the gastric wall due to local loss of muscular contractility is a valuable sign. In such instances a wave may progress to the affected site, skip it, and take up its course again beyond, and this observation is one test for the genuineness of cancerous filling-defects. Weak peristalsis, the waves being both shallow and infrequent, is fairly common in cancer. Frequently the stomach seems to be perfectly inert. Antiperistalsis is occasionally observed in cancer with pyloric obstruction. The antiperistaltic waves are best seen on the greater curvature in the pars pylorica and media. The waves, though sometimes deep, are usually wide and shallow. Beginning at the pylorus, they sweep slowly backward and disappear in the upper pars media. They may coexist with peristaltic waves traveling in the normal direction. Exaggerated peristalsis, as a sequence of cancer with pyloric obstruction, is more rare than might reasonably be supposed. When seen, the exaggeration is usually more marked on the greater curvature. It may be irregular as to the depth and succession of the waves; a fairly deep wave may be closely followed by a shallow one, while the next may be normal as to depth and rhythm. None of the foregoing perversions of peristalsis is peculiar to cancer, and they are merely indicative of a pathologic process.

Altered Motility.—Emptying of the cancerous stomach may be either retarded or accelerated, according to the presence or absence of pyloric obstruction. In the non-obstructive cases

hypermotility is the rule, and is a natural sequence of the achylia and gaping pylorus. The acceleration of gastric clearance may be extreme and the stomach may evacuate itself with extraordinary rapidity. The acceleration is exhibited often not only in a rapid and early clearance of the stomach, but also in an advanced position of the six-hour meal, the head of the barium column appearing in the transverse colon, the splenic flexure, the descending colon, or even the ampulla. In the obstructive cases, delayed clearance is shown by the six-hour residue. That portion of the meal which has passed through into the intestine may or may not show retarded progress. It is to be remembered that gastric motility may be affected by many lesions other than cancer. Hypermotility of moderate degree is a common result of non-obstructive duodenal ulcer, achylia, and diarrheic conditions. Hypomotility, with or without a six-hour retention, may result from any sort of organic obstruction at the pylorus or just beyond, or from reflex pylorospasm.

Lessened Mobility.—Exceptionally, when it involves adjacent structures, a cancer produces more or less fixation of the stomach. The attachment may be to the abdominal wall, or to the liver, pancreas, or other viscera. The presence of fixation may be determined sometimes, but not always, by palpatory maneuvers, depending upon the position of the stomach, the situation of the attachment, and the degree of laxity of the abdominal wall, and, also, by observation during forced respiration. The small, high-lying, contracted stomach, inaccessible to manipulation, may appear to be fixed but is not necessarily so. On the other hand, a stomach which has a free and flexible lower pole may seem to be freely mobile when there are definite adhesions on the lesser curvature. Inasmuch as fixation is simply an indication of extra-gastric involvement, it is merely a contributory sign of cancer. It may be taken into account in estimating the possibility of resection.

Lessened Flexibility.—Diminished flexibility of the cancerous gastric wall is a practicable and useful sign, especially of scirrhous cancer. Upon narrow palpation, as with the finger

tips, the accessible normal gastric wall will show corresponding indentation, whereas if stiffened by infiltration it will either be disproportionately indented or moved aside *en masse*. The loss of pliability may be somewhat evident also by the lack of change in contour during deep respiration or during the process of filling the stomach, the lumen of the involved area being almost constant in size at all degrees of repletion, while the unaffected portion expands to accommodate the increased volume.

Persistent Local Spasm.—A cancer on the lesser curvature or on the posterior wall may give rise to a spastic indrawing of the greater curvature. Often it is quite broad and has been spoken of as the "broad incisura" of cancer as compared with the relatively narrow incisura of ulcer. Besides the "broad incisura," the deformity produced by the growth itself is commonly observable. I have seen exceptional cases, however, in which an incisura from cancer was narrow, resembled a typical ulcer-incisura, and was the only demonstrable roentgenologic sign of the lesion. Such spasm may, of course, be imitated by spasm from extrinsic causes, and careful differentiation may be necessary. Again, an occasional case of gastric cancer will be seen in which a shifting, more or less diffuse, spasm is the only evidence obtainable, and a diagnosis is impossible.

Altered Size and Capacity.—A common feature of the cancerous stomach is marked diminution of the capacity and apparent size. The reduction may be the result either of the projection of large fungoid masses into its lumen or the shrinking effect of scirrhous infiltration. In extreme instances, the effort to accommodate the ingesta causes a backing up of the meal in the esophagus, which latter may show dilatation. Besides cancer, other causes that may lessen the capacity of the stomach are perforating ulcer, with extensive perigastritis, spasm, and benign lesions. The upper loculus of an hour-glass stomach may be mistaken for a contracted stomach if the presence of the lower loculus is not immediately visualized. On the other hand, an obstructive cancer at the pyloric end may result in considerable dilatation of the stomach. A similar dilatation may be conse-

quent upon other obstructive causes. It follows, then, that neither large nor small size of the stomach is especially significant of cancer, but that marked variation in size of the stomach is at least suggestive of the presence of a lesion.

Displacement.—The predilection of cancer for the pyloric end of the stomach, often with more or less complete obliteration of the distal portion of its lumen, results frequently in an apparent displacement of the stomach to the left, since its proximal portion only is visualized. Aside from this, however, in cases of scirrhous cancer, there may be actual displacement upward and to the left. Somewhat similar displacements may occur as a result of perforated ulcer, ascites, tumors outside the stomach, and retraction of the abdominal wall.

Pathology.—With the microscopic pathology of gastric cancer the roentgenologist has little concern, but the roentgenologic appearances of cancer sometimes depend quite considerably upon its character as affecting its form, location, and extent. Hence, a few statements concerning certain anatomic varieties of cancers and their gross aspects may assist in clarifying the description of this lesion as seen by means of the roentgen-ray.

Cancers of the stomach invariably originate in the mucous layer. While basically they are all epithelial neoplasms, they present numerous structural differences. Disregarding those variations which are here unimportant, there are three forms which are of chief interest from a radiologic standpoint:

1. A proliferative form, almost wholly epithelial in composition, with circumscribed tumor production. This is the *fungous* type with which may be included for present convenience the medullary (encephaloid), cauliflower and adenocarcinomas. It is characterized by a relatively small amount of connective tissue, and hence is soft.

2. An infiltrative form. This is the *scirrhous* type. Speaking in a general way, it infiltrates the gastric wall with less unevenness of contour and less projection into the cavity of the stomach than the fungous type. It is characterized by a relatively large amount of connective tissue, and is hard and more

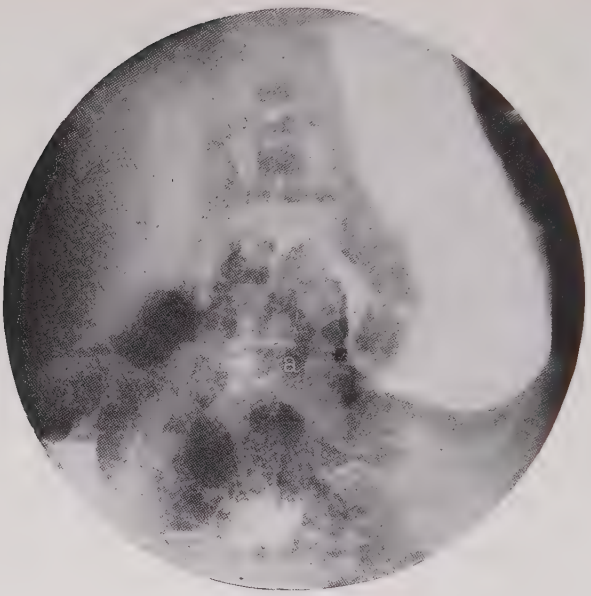

FIG. 133.—Filling-defects produced by fungous carcinoma, shown in Fig. 134.

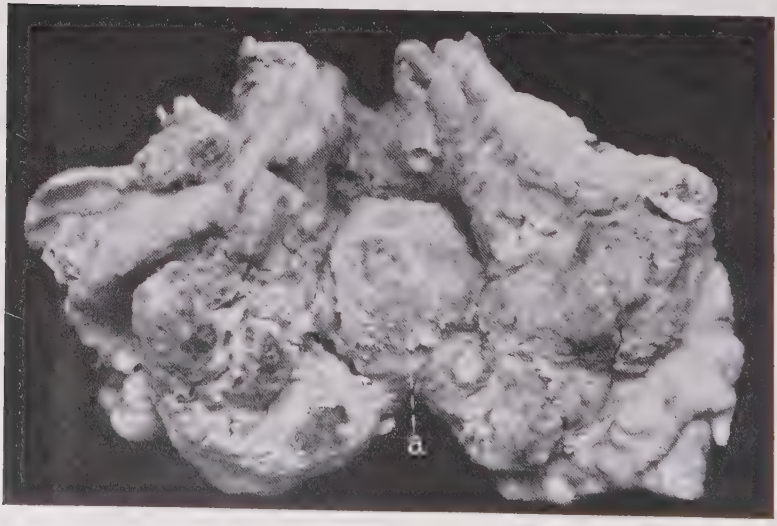

FIG. 134.—Photograph of specimen, showing fungous (medullary) type of cancer. The rounded mass at *a* corresponds to the circular filling-defect in the roentgenogram, Fig. 133.

frequently associated with ulceration than the other types. The infiltration may be either localized or general. When localized, the pyloric end of the stomach or the lesser curvature is the part most commonly affected. The general diffuse infiltration may involve a large part or the whole of the stomach, which is thick-walled and contracted. This is regarded by many as identical with the so-called "leather-bottle" stomach, or "diffuse fibrosis."

3. A degenerative form, the so-called "colloid," or, more correctly, "mucoid" cancer. In this form the cells lose their structure and become merged into a homogeneous mucoid mass. Mucoid degeneration may occur in either the fungous or scirrhous type.

Roentgen Characteristics of Fungous Cancer.—In a broad way the typical fungous cancer shows the following characteristics:

1. It does not decrease the size of the stomach as a whole. While the capacity of the stomach may be somewhat lessened by the encroachment of the mass upon its lumen, the gastric dimensions are not otherwise diminished. Often the hook-form is preserved (Figs. 133 and 134).

2. Occasionally it involves the greater curvature only, especially of the body of the stomach (Fig. 135).

3. The involved portion of the gastric wall is sharply delimited from the uninvolved portion.

4. Sometimes it produces large, multiple, irregular filling-defects projecting into the gastric lumen and shading gradually into the central barium shadow, somewhat resembling finger-prints upon paraffin (Fig. 136).

5. If situated at the pyloric end this type is likely to produce obstruction.

Roentgen Characteristics of Scirrhous Cancer.—Typical advanced scirrhous cancer may be recognized by:

1. Its marked shrinking effect upon the stomach. The capacity of the stomach is not merely lessened by a filling-defect, but is greatly diminished by the loss of expansibility, due to widespread infiltration as well as actual contraction.

FIG. 135.—Irregular filling-defect, greate rcurvature, body of stomach, at *a*, due to fungous cancer.

FIG. 136.—Finger-print-like filling-defects of fungous cancer.

2. Frequent involvement of the pyloric end and lesser curvature. Often a scirrhus completely encircles the pyloric end and the deformity thus produced gives the stomach some resemblance to a curved funnel or an Indian pipe. The barium projects into the canalized pyloric mass as a smooth or slightly irregular spicule.

3. Gradual merging of involved into non-involved portion of the gastric wall. The limits of the lesion are difficult or impossible to determine radiologically. The lesion is usually more extensive than the picture indicates.

4. The filling-defects of scirrhous cancer are less grossly irregular than those of the fungous type (Figs. 137 and 138).

5. The scirrhous cancer, even though it involves the pars pylorica, is likely to show a gaping pylorus; it may, however, produce obstruction.

Mucoid Cancer.—A markedly diminished, fairly regular central lumen surrounded by a thick-walled tumor-mass is sometimes seen in extensive mucoid degeneration, but mucoid change can rarely be even surmised by the radiologic appearances. It gives practically the same screen and plate picture as the scirrhous form.

It will be understood that the three forms mentioned do not always or necessarily exist independently of each other, that the classification and descriptions are practical rather than accurate, and that differentiation of these forms is not always easy. Sometimes these pathologic differences in gastric cancers are sufficiently manifest in the roentgenologic picture to warrant an opinion as to their probable nature. However, such an opinion should be advanced with caution, and then only in those rather few cases which are typical, for, in the majority of cases, the roentgenologist had better be content with a diagnosis of cancer without attempting to specify the particular variety.

Carcinomatous Ulcer.—While by far the greater number of gastric cancers manifest themselves frankly as tumors at the time the patients present themselves for examination, ulcers

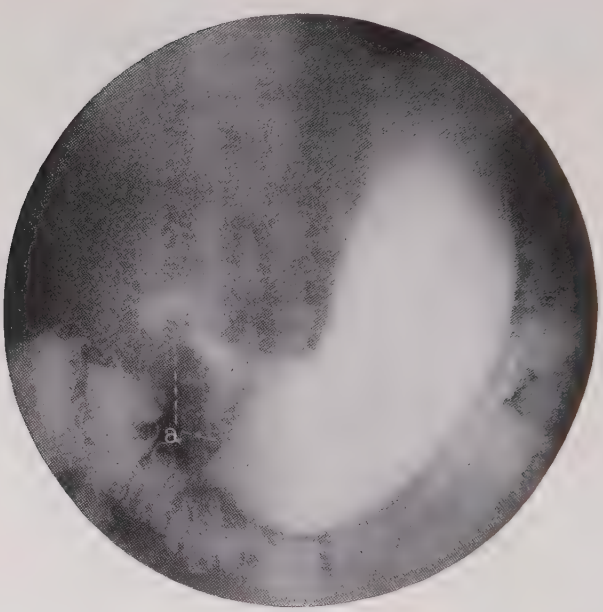

FIG. 137.—Uniform, wedge-like prepyloric narrowing at *a*, in a case of scirrhous cancer See specimen Fig. 138.

FIG. 138.—Photograph of resected pyloric end of stomach. Scirrhous cancer. See roentgenogram Fig. 137.

are found occasionally which show microscopic evidence of malignancy. In their gross characteristics and roentgenologic appearances these ulcers are not usually different from benign ulcers. In most instances the crater of the ulcer is visualized as a niche projecting from the gastric lumen. This may or may not be associated with hour-glass stomach, an incisura, or six-hour retention. The only suspicious feature sometimes shown by the roentgen-ray is the extraordinarily large size of

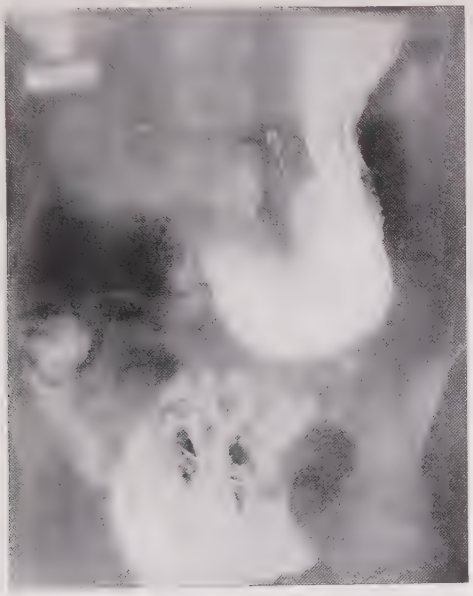

FIG. 139.—Very large ulcer crater at *a*. Malignant.

the ulcer crater. In a few of our own cases in which the niche was 3 or 4 cm. broad the ulcer was found on microscopic examination to be malignant (Fig. 139). However, ulcers of small size may occasionally show carcinoma cells in the margin.

Operability.—In deciding the question of operation in a given case of cancer of the stomach, the x-ray may furnish information of great, often of decisive, importance. Primarily, operability depends on the skill and judgment of the surgeon; but aside from this, certain roentgen findings speak for or against opera-

tion, whether radical or palliative. The location, extent, and character of the cancer are all matters of fundamental importance.

According to the x-ray evidence of operability the possibility of curing a particular lesion depends on its location in one of three zones, operable, borderline, or inoperable. The limits of each zone are roughly marked by the roentgen divisions of the stomach. The operable zone corresponds to the pars pylorica, the borderline zone to the pars media, and the inoperable zone to the pars cardiaca.

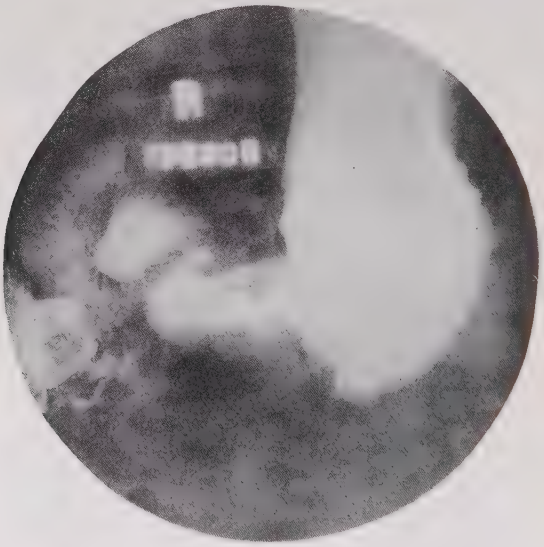

Fig. 140.

Tumors in the operable zone are those which are shown by the x-ray to be operable in so far as the stomach is concerned (Fig. 140). In this zone are included those lesions which have not spread far on the stomach wall to the danger zone, the pars media. Often cases which present such symptoms clinically as to seem inoperable prove operable on x-ray examination, for even a very large palpable tumor may be resected if it is confined to the lower half of the stomach. While a palpable tumor does not, therefore, prevent surgical intervention, it does mean that the lesion has existed for some time and that metastasis

may be present; but as we seldom know that metastasis is present, a tumor of the pyloric third of the stomach, even though palpable, is considered operable. Of course, not every palpable tumor of the stomach is cancer; the mass may be a perforated ulcer with adhesions, pancreatic cyst, floating spleen, or a lesion originating in the gall-bladder.

A lesion of the stomach can be pronounced operable, however, only with respect to the stomach, since perforation and metastasis almost invariably remain undiscovered until after incision. The clinician can prevent useless operations in some cases indicated as operable by the x-ray, since he can find metastasis to the rectal shelf, supraclavicular glands, umbilicus, or skin; ascites when associated with a history of malignancy is also a fairly reliable index of inoperability. Gross metastasis to the lungs and bones is roentgenologically demonstrable, but it is so rare in cases of cancer of the stomach as to merit no more than mention. The presence of nodular metastasis on the upper surface of the liver, deforming the arch of the diaphragm, may rarely be observed by the x-ray. Abdominal metastasis, the most frequent form, is a condition which neither the x-ray nor any other method of pre-operative examination can discover and which the surgeon is unable to cope with, even whea the tumor is in the most favorable location for resection.

The tumors of the borderline zone are those which extend so far toward the cardiac end of the stomach that their resection becomes uncertain (Fig. 141). These cases present the most puzzling problems of operability from a roentgenologic standpoint. The position and size of the stomach may be a surgicnl drawback; the small high-lying stomach of the robust person offers much greater difficulty to the operator than does the relaxed stomach of the asthenic person. Therefore, if the roentgenologist is familiar with the surgeon's technic he can better form his decision as to the operability of the particular case than if he knows nothing of the operator's dexterity and willingness to attempt resection when the tumor lies in the borderline zone of the stomach. The nearer the lesion approaches the inoper-

FIG. 141.

FIG. 142.

able zone, the more adept must be the surgeon in order to work high up under the costal arch and to remove just enough of the stomach so as to leave it free from neoplasia (Fig. 142).

Tumors of the fundus which do not produce pyloric or cardiac obstruction and which are not palpable because of their high location may exist for some time without causing much inconvenience; by the time clinical diagnosis is definite they are usually inoperable. Also, when a tumor is in a questionable position with regard to operability allowance must be made for the type of tumor and consequent type of invasion of the stomach wall. The fungoid carcinomas produce multiple, irregular filling-defects, and the real extent of the cancer is quite closely delineated by the roentgen shadow, while the scirrhous cancer produces a less gross filling-defect which may gradually shade off and not picture the true limits of the disease. Even after allowing for an excess of involvement of a scirrhous cancer beyond that indicated, exploration may reveal inoperable conditions. Since free mobility of a cancerous stomach favors resectability; since fixation resulting from extension to adjacent organs makes successful intervention less probable; since cancer roentgenologically demonstrated as small may on operation be found to have invaded or become adherent to adjacent organs, and since metastasis may exist without detection by the x-ray, the roentgenologist is forced to make such a relative diagnosis of operability of the tumors of the borderline zone that this might be called the exploratory zone, for on the surgeon devolves the operative decision. Besides, there is always at least a remote chance that the most confident diagnosis may be wrong.

A filling-defect corresponding to a palpable mass on the convexity of the greater curvature, especially when associated with a fixed or partially fixed stomach, should suggest the possibility of involvement of the colon which may be definitely determined by examination with the opaque enema, the ingested meal, or both.

In the inoperable zone are the gastric tumors which are pointed out with finality by the x-ray as inoperable. The

tumors of this zone are located in the cardiac end of the stomach or they have spread from a pyloric or fundal carcinoma to within this uppermost zone (Fig. 143). Surgery can bring no relief to the patient when the cardiac portion of the stomach is cancerous. The tumors in this region of the stomach are easily recognized as inoperable by the x-ray.

Statistics of cancer of the stomach show an appalling number of inoperable cases, especially when it is considered that surgery

Fig. 143.—Cancer of cardia. Inoperable.

can bring cure early in the course of the disease. The high mortality of cancer of the stomach may be largely attributed to too-late diagnosis. The x-ray can now discover 95 per cent. of all gastric cancers, of which about 50 per cent. are still in an operable stage. Another decisive value of the x-ray is the prevention of operation in inoperable cases. When routine examinations of persons presenting gastric symptoms become a reality, the x-ray should be able to increase the number of operable cases, for the inoperable tumors should be practically

only those which cannot be resected because of cardiac location. Carcinomas of the cardia, however, represent a small percentage of gastric cancers.

Early Cancer.—The term "latent cancer" is sometimes applied to cancers which give rise to few or no symptoms or signs and which cannot be diagnosed clinically. Since "latent" also carries the sense of quiescence or dormancy, a condition which has not been proved as regards gastric cancer, the adjective "early" is perhaps preferable.

Admitting that the only cure for cancer is early operation, early diagnosis is a matter of prime importance. Admitting also that usually there are no decisive clinical findings in early cancer, the statement is warranted that next to the exploring finger of a trained surgeon the roentgen-rays will reveal more cancers in the early stages than will any other diagnostic means. Hence every patient of cancer age with indefinite gastric symptoms should be subjected to a roentgen examination. The earliest time at which cancer may be found depends upon:

1. The character of the cancer, whether a frank tumor, an insidious infiltration or a cancerous ulcer.
2. Its situation.
3. The examiner's familiarity with the work.
4. The amount of roentgenologic evidence, together with the extent of clinical corroboration.

Cancer which begins candidly as a tumor projecting into the gastric lumen is susceptible of quite early recognition by reason of the filling-defect which it produces (Fig. 144). The test of this sign is its permanence, not its size, and I have been fortunate enough to find a cancer which was not larger than 2 cm. in diameter. An infiltrative cancer may invade the gastric wall without producing a recognizable filling-defect. In this event peristalsis should be notably absent from the involved area, and a local loss of flexibility may be evident on palpation. When these signs exist alone they should be interpreted with caution; but in conjunction with a gaping pylorus, achylia and clinical indices, they may warrant a surgical exploration.

Carcinomatous ulcers for the most part show the same roentgenologic signs as simple ulcers. However, as stated, ulcers with excessively large craters are open to the suspicion of being cancerous.

The situation of a small cancer makes a decided difference in the chance of its demonstration. On either curvature of the pars media or pars pylorica, filling-defects, even though small, can usually be visualized on the screen or plate, or both; but

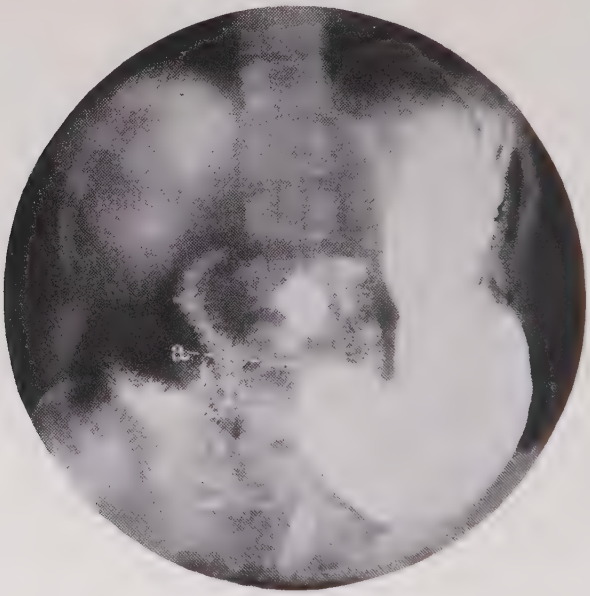

Fig 144.—Deformity, *a*, at pylorus due to early cancer.

such defects on the anterior or posterior wall might evade observation even in the oblique view. Trifling defects in the region of the gas-bubble also are hard to find. The percentage of cancers in the pars cardiaca, however, is small.

The experience of the examiner and his ability to see and interpret slight departures from the normal have some importance in the diagnosis of early cancers. The novice would better limit his diagnoses to those cases in which he can demonstrate a permanent filling-defect, and which are at least suspicious clin-

ically. These features will be found in the greater number of patients with gastric cancer who seek medical aid.

Patients with early cancer near the pyloric ring, producing obstruction, are more likely to come into the hands of the roentgenologist than patients with early cancer beginning elsewhere in the stomach. A six-hour retention, evidencing obstruction, may be the only abnormality of which the observer feels sure. This alone, of course, will not support a diagnosis of cancer. In other cases there may be a slight but permanent irregularity of prepyloric contour, with or without obstruction, and it can be said with certainty only that a lesion is present. Correlation with other evidence may help to decide whether it is an ulcer, a cancer, or something else.

While it is highly important that gastric cancers shall be discovered at the earliest possible moment, it is also highly important that the patient shall not be subjected to needless surgery, and where the roentgen findings plus the clinical features of the case do not quite justify surgical exploration the patient should be reëxamined at short intervals until a decision is reached.

The roentgen indications of gastric cancer vary markedly in degree and in their combinations with each other, as will be seen in the case reports herewith appended. The cases with which the roentgenologist has to deal thus range all the way from those which are plainly cancer to those which are highly doubtful. Often he can be positive only of a pathologic condition. In every case he should be acquainted with the principal clinical facts, which should at least grossly correspond to his own findings. If they do not agree, he should confirm his own observations by repeated examinations.

Case 90,077, female, aged 53. Fourteen months ago the patient began losing weight and strength, notwithstanding a good appetite. Occasionally she has had nausea about an hour after meals. Six months ago a physician made a gastric analysis, found an achlorhydria and gave hydrochloric acid with some benefit. For two months past she has had a persistent diarrhea. Weight loss, 41 pounds.

Vague sense of tumor-ridge in epigastrium. Total acidity 22, all combined; altered blood. Hemoglobin, 55. Roentgen findings: No six-hour retention. Gross filling-defect, greater curvature, pars media (Fig. 145). Shading off in lesser curvature of pars cardiaca. Diagnosis: Inoperable carcinoma. (In spite of the evident inoperability the patient insisted upon surgical exploration.) Finding at exploration: Inoperable carcinoma of body of stomach. Extensive glandular involvement.

Case 102,053, male, aged 56. Many years ago the patient had several attacks of sudden, severe, epigastric pain, often requiring morphin, but has had none of these attacks during the past ten years. His present trouble began eight months ago and consists of an indefinite distress and soreness in the epigastrium, coming three or four hours after meals and relieved by food. Appetite good. Net weight loss 20 pounds, but none during past four months. Total acidity 10; all combined. Roentgen findings: No retention from six-hour meal. Filling-defect, pyloric portion (Fig. 146). Diagnosis: Cancer. Considered operable in so far as extent of gastric involvement was concerned. Findings at operation: Carcinoma pyloric end of stomach. Resection half of stomach. Pathologist's report: Carcinoma.

Case 109,744, female, aged 38. Eleven months ago she began having slight attacks of pyrosis and epigastric distress. Later the epigastric distress became rather spasmodic but was not severe, had no food relation, and the attacks were very brief in duration. Generally considered, pain has not been a marked feature. She has vomited but twice. Nine months ago she first noticed a small, very movable tumor in the epigastrium a little to the left of the midline. This has since increased slightly in size. Poor appetite. Weight loss, 20 pounds. Palpable, movable tumor, the size of a fist, very like a wandering spleen. Hemoglobin, 68. Roentgen findings: Retention of one-fourth the six-hour meal. Definite prepyloric filling-defect (Fig. 147). Findings at operation: Carcinoma, pyloric end of stomach, adherent to pancreas and transverse mesocolon. Resection three-fifths of stomach. Pathologist's report: Carcinoma.

Case 97,408, male, aged 43. Five years ago the patient had occasional attacks of vomiting, sometimes of food taken the previous day. These ceased after medical treatment and the patient was well until five weeks ago. At this time he began to have attacks of epigastric pain, aggravated by exercise and relieved by rest. No food relief. Occasionally takes hot water or soda at night to relieve the pain. No loss of weight. Total acidity 86; free 62; combined 24; no food remnants. Roentgen findings: Retention of half the six-hour meal.

FIG. 145.—Case 90,077 Roentgenogram showing appearance of medullary type of cancer at *a*.

FIG. 146.—Case 102,053. Cancer defect at *a*.

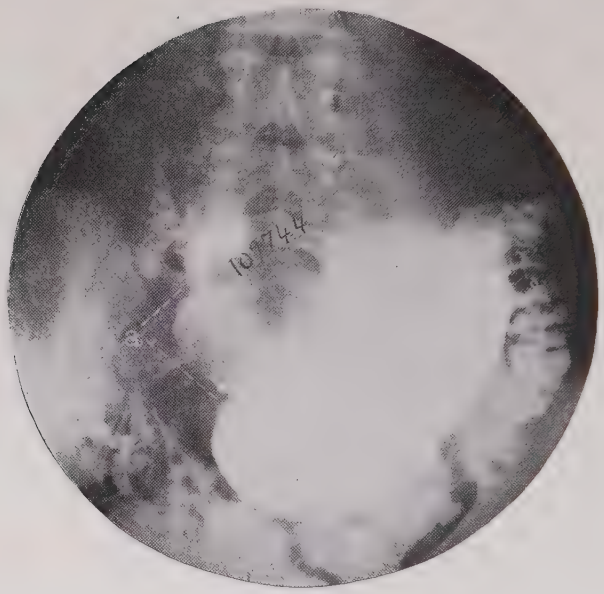

FIG. 147.—Case 109,744. Cancer deformity at *a*.

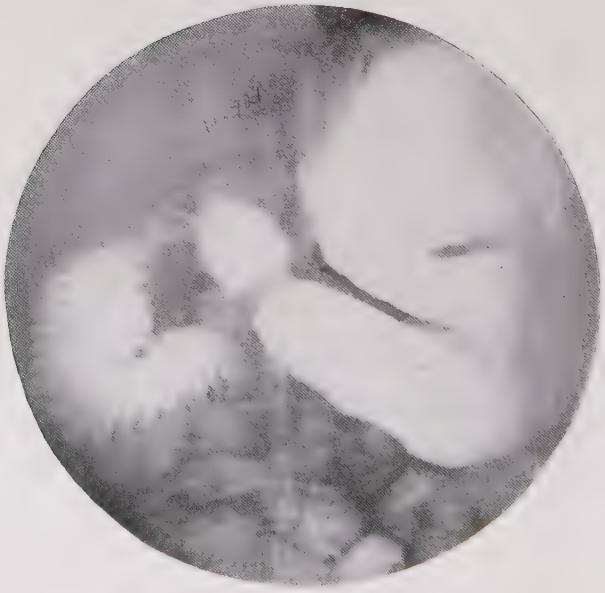

FIG. 148.—Case 142,921. Deep, narrow incisura, body of stomach.

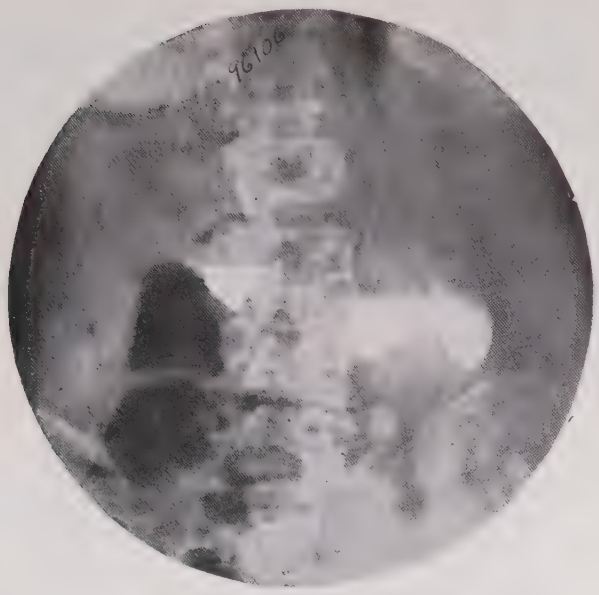

FIG. 149.—Case 96,106. Six-hour residue.

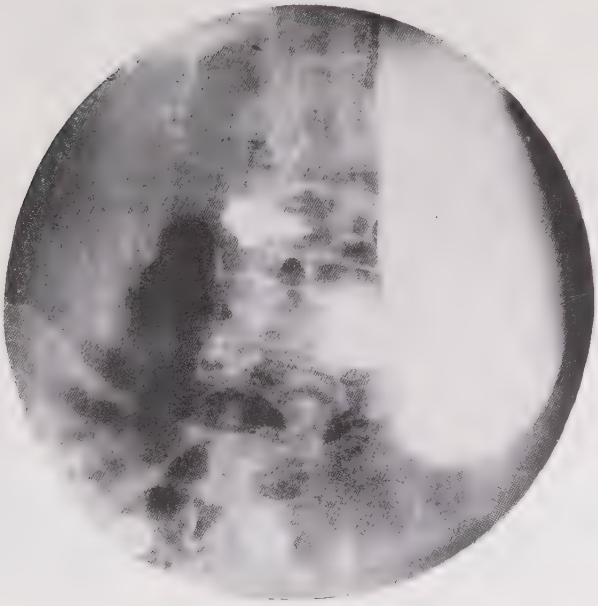

FIG. 150.—Case 96,106. Stomach after filling. The prepyloric deformity is evident.

Small prepyloric filling-defect (Fig. 144). Active peristalsis. Diagnosis: Lesion at the pylorus. (As the pathologist's report shows, this proved to be an ulcer with early carcinoma. Many similar cases diagnosed roentgenologically as cancer prove to be ulcer and *vice versa*. Therefore, in the absence of pathognomonic signs, the roentgenologist will spare himself embarrassment by simply reporting the presence of a lesion, and leave the final diagnosis to the microscopist.) Findings at operation: Early carcinoma on ulcer, pyloric end of stomach. Resection 10 cm. of stomach; duodenum reattached to pyloric end, direct union. Pathologist's report: Ulcer; early carcinoma.

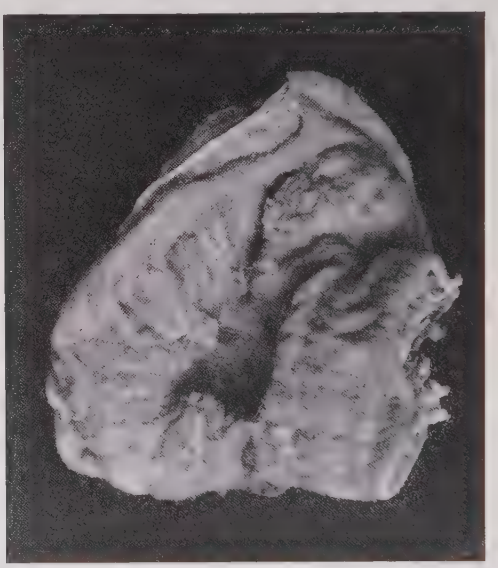

FIG. 151.—Case 96,106. Resected pyloric end of stomach. Ulcerating carcinoma

Case 142,921, female, aged 32. Five-year history of severe epigastric pain daily for a period of about three months each year, beginning in June or July. At first the pain came within a few minutes after meals. Now comes about one hour after eating, is of variable duration and is eased by posture, food and medicines. In attacks may vomit three or four times daily. Copious hematemesis two years ago. Some weight loss. Roentgen findings: No six-hour retention. Incisura, pars media. No niche or filling defect on lesser curvature. The possibility of an ulcer was thought of and the patient was rerayed after being given belladonna. At the second examination the incisura was still present. Diagnosis: Gastric ulcer. (It is interesting to

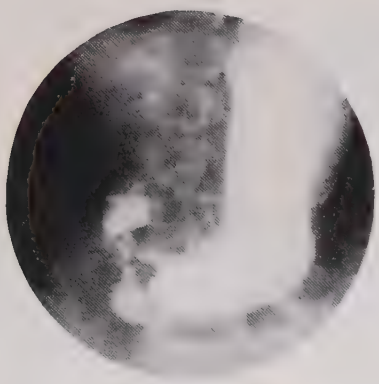

FIG. 152.

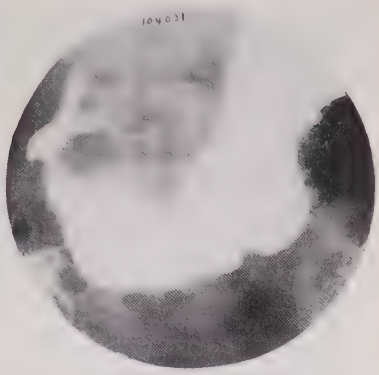

FIG. 153

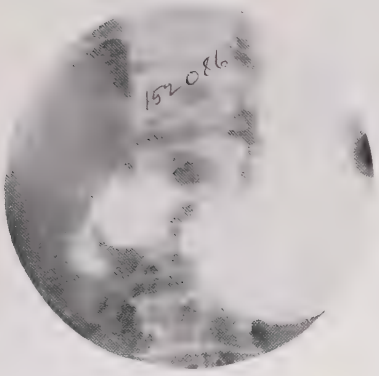

FIG. 154.

FIG. 155.

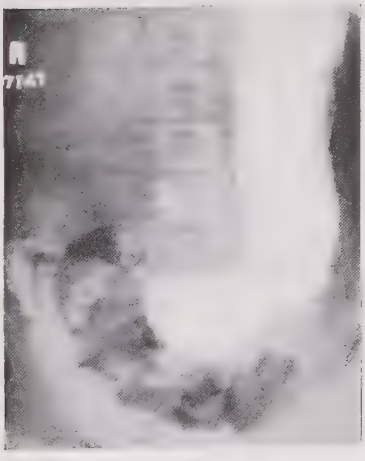

FIG. 156.

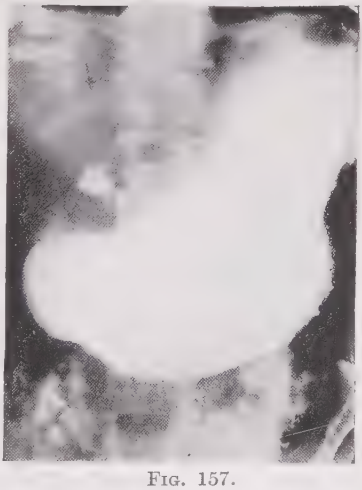

FIG. 157.

FIGS. 152, 153, 154, 155, 156, 157.—Cancers of the stomach; resectable.

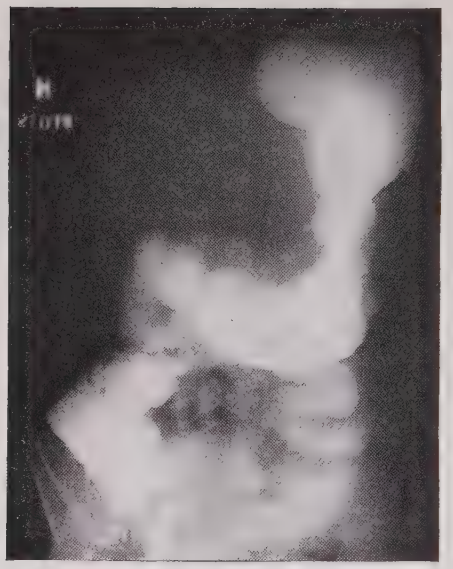

Fig. 158.

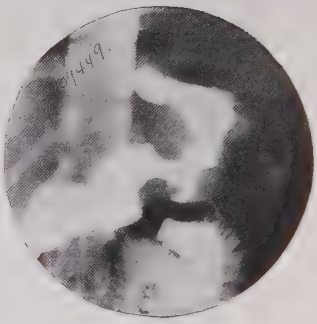

Fig. 159.

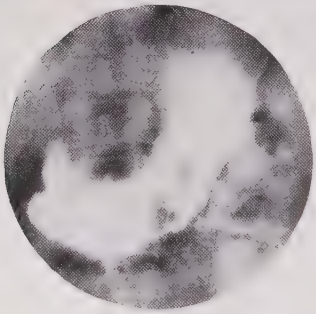

Fig. 160.

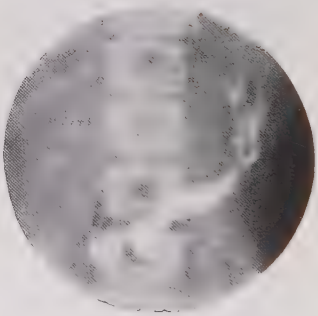

Fig. 161.

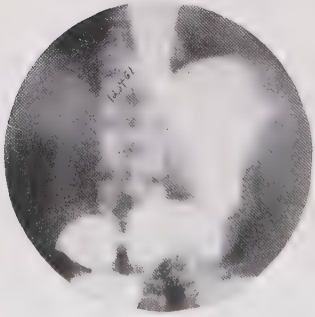

Fig. 162.

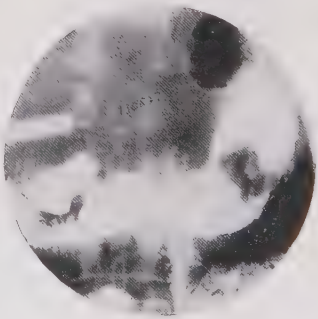

Fig. 163.

Figs. 158, 159, 160, 161, 162, 163.—Cancers of the stomach; inoperable.

note that the persistent incisura was the only roentgen sign observable, either on the screen or plate (Fig. 148). Findings at operation: Ulcer lesser curvature, 4 cm., producing hour-glass deformity. Excision; posterior gastro-enterostomy. Pathologist's report: Section of ulcer shows colloid carcinoma.

Case 96,106, a woman, aged 41. Cholecystectomy seven years ago for cystic gall-bladder with stones. Three years later operation for acute strangulated left inguinal hernia. Since the latter operation, she has had occasional sharp sticking pain in the left hypochondrium. For a month past she has had dull epigastric pain immediately after meals with relief by bowel-movement. During the past two weeks the pain has been constant. Appetite good, but she is afraid to eat. Weight loss, 20 pounds. On palpation a hard mass can be felt in the epigastrium, which moves with inspiration. Gastric analysis: Total acidity 14, all combined; food remnants, mucus, blood. Roentgen findings: Retention of half the motor meal after six hours (Fig. 149). Concentric prepyloric filling-defect corresponding to a palpable mass (Fig. 150). Diagnosis: Cancer; operable so far as extent of gastric involvement is concerned. Findings at operation: Cancer, pyloric region, involving both curvatures. Edema in gastro-colic omentum. Resection of two-thirds of stomach. Anterior gastro-enterostomy. Resection of portion of mesentery of transverse colon. Pathologist's report: Cancer (Fig. 151).

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CHAPTER X

FIBROMATOSIS OF THE STOMACH

Leather-Bottle Stomach, Cirrhosis, Fibrosis, Linitis Plastica

The "leather-bottle stomach" to which Brinton[1] gave the name "linitis plastica" has occasioned considerable difference of opinion as to its malignancy. Brinton regarded the condition as benign, his view having eminent indorsement; but many pathologists are either skeptical of its benignancy or firmly of the opinion that it is malignant. Thompson[2] says: "The controversy owes its origin to the fact that there occurs in the stomach a diffuse infiltrating form of scirrhous cancer which in its distribution resembles fibromatosis, while at the same time it differs so much in its naked-eye and microscopic appearances from the classical forms of gastric carcinoma that its true character is not capable of being established without a thorough histologic examination." Such stomachs, from their gross appearance, are often described by the surgeon as being of the leather-bottle variety, although painstaking microscopic examination will reveal the presence of cancer-cells. The confusion is shown also by the large number of synonyms, one of which is "diffuse carcinoma," and is increased by the fact that fibromatosis may occur in association with cancer, which latter, as viewed by the partisans of the benignancy of the leather-bottle stomach, is regarded as a superaddition. Further, the question has perhaps been somewhat involved with syphilis and tuberculosis of the stomach.

Fibrosis may be either localized or diffuse. When localized it is said to have a predilection for the pyloric portion. Ulceration of the mucosa, either circumscribed and deep, or widespread and shallow, is reported in the majority of cases. In the diffuse form, the stomach is diminished in size, and is converted into a stiffened tube which does not collapse when opened. On

microscopic section, the submucosa is found converted into firm, tough, white, fibrous tissue, up to a centimeter or more in thickness. The muscularis is hypertrophied and shot through with fibrous septa. A number of cases reported showed no cancer cells. Whether a more prolonged and careful search might possibly have revealed such cells is a matter of doubt.

From a clinical standpoint McGlannan[3] gives the following summary: "The disease is one of adult life. Lyle's[4] statistics show that the greatest number of cases occur between the ages of 40 and 60 years, and about twice as often in men as in women. Some form of disease associated with general circulatory stasis is frequently noted in the previous history of the patient. The symptoms of onset are generally slight indefinite dyspepsia (Lyle), loss of appetite, epigastric distress on taking food, and eructations. The symptoms gradually become marked and progressive, reaching those of definite stenosis, and, if unrelieved, end in anemia, starvation, cachexia and death. Occasionally the onset is quite abrupt, and the obstructive symptoms come on rapidly. Gastric examination shows a diminished capacity of the stomach, and the stomach cannot be distended. The thick stomach has been palpated as a sausage-shaped tumor in the epigastrium. Chemical examination of the contents usually shows diminished acidity with little or no free hydrochloric acid. Lactic acid may be present. Blood either in stomach contents or feces is unusual. Roentgen examination offers the best means of recognizing the lesion."

The roentgenologic manifestations of the condition are practically identical with those of cancer, more particularly those of scirrhous cancer. The filling-defect produced by the thickened wall is likely to have a relatively smooth inner margin, and a corresponding mass may be felt. Peristalsis is absent from the involved area. The pylorus is either gaping or obstructed. When the involvement is extensive there is a striking lack of expansibility and flexibility, and the stomach is small, contracted and drawn upward. When the process begins at the pylorus and produces obstruction early, dilatation of the stomach results.

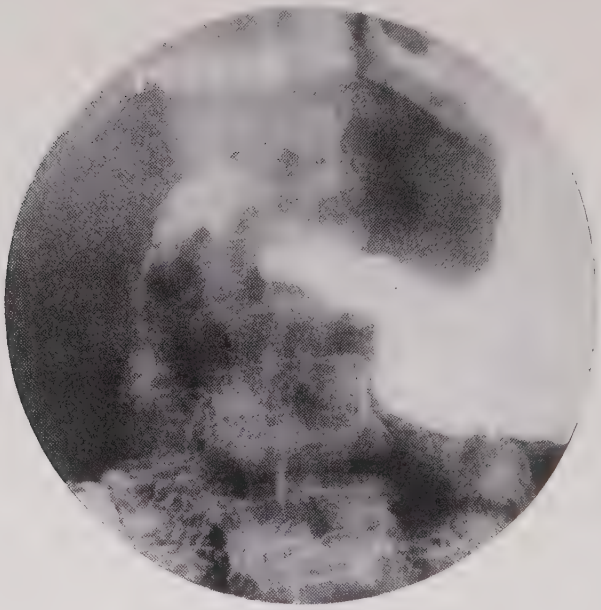

FIG. 164.—Case 146,919.

FIG. 165.—Case 102,013.

Case 146,919, male, aged 52. For two years he has had brief attacks of nausea occurring about once a week and mostly when stomach was empty. A year ago he had some tenderness and epigastric pain, an hour after meals, relieved by vomiting. These attacks ceased and he felt well until three months ago, when food seemed to lag at the cardia but passed into the stomach after belching. He vomits if he eats rich or large amounts of food. Weight loss, 16 pounds in three months. Mass in the epigastrium moving with respiration. Total acidity 6, all combined. Roentgen findings: No retention from the six-hour meal. Gaping pylorus. Prepyloric filling defect; lumen smoothly narrowed (Fig. 164). Palpable mass corresponding to defect. Diagnosis: Cancer. Findings at operation: Tumor beginning at pylorus, extending onto lesser curvature about 7.5 cm. Pylorus freely movable. Growth not causing marked obstruction. Leather-bottle type of stomach. Resection. Pathologist's report: Ulcer. Greatly thickened submucosa and musculature with marked round-cell infiltration and fibrosis. Unable to make definite diagnosis of carcinoma.

Case 102,013, female, aged 69. Two years ago she noticed the sensation of a lump in her stomach soon after meals. A year later she could feel a mass in the epigastrium which has since steadily increased in size. Eight months ago she began vomiting immediately after meals, without pain or nausea, but because of fullness even when taking ordinary amounts. Appetite good. Weight loss, 45 pounds. Oblong mass palpable in epigastrium. Total acidity 6, all combined; no food remnants. Hemoglobin 85. Roentgen findings: No retention. Gaping pylorus. Stomach small and irregularly contracted. Walls not flexible to palpation. No peristalsis seen. Diagnosis: Cancer (Fig. 165). Findings at exploration: Inoperable tumor involving entire stomach. Leather-bottle stomach. Some glandular thickening but no metastasis. No microscopic diagnosis.

Case 124,629, male, aged 44. Eight months previously the patient began to have epigastric pain, coming immediately after the meal and lasting to one hour. The attacks continued until six weeks ago since when he has felt quite well. Weight loss, 15 pounds. Fairly firm tumor to left of umbilicus, visibly modified in shape by peristaltic wave (?). Total acidity 66; free 60; combined 6; mucus. Roentgen findings: No retention. Gross filling defects lower two-thirds of stomach, changing in aspect with palpation and shifting of patient. Without any correlation with the clinical history, the condition was believed to be an extra-gastric tumor (Fig. 166). Findings at operation: Huge leather-bottle stomach, flattened out, involving all of

stomach except the cardiac end. Tumor forming a mass shaped exactly like a large water-bottle. Carcinoma. Resection of three-fourths of stomach. Pathologist's report: Carcinoma with no glandular involvement.

Fig. 166.—Case 124,629.

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CHAPTER XI

SYPHILIS OF THE STOMACH

The difficulty of substantiating a diagnosis of gastric syphilis has given rise to much skepticism as to the frequency of its occurrence. For proof, reliance must be placed on the history, the co-existence of syphilitic lesions elsewhere, the Wassermann or Noguchi reaction, the examination of the spinal fluid, the improvement after antiluetic treatment, and the microscopic examination of tissue exsected from the stomach.

Eusterman[1] divides the literature on gastric syphilis into three periods: The first period extends from the report of Chiari in 1891 to 1905, and deals largely with post mortem material. The second period extends from 1905 to 1910 and the diagnosis of the cases reported was made largely from the history and antispecific treatment. The third period extends from 1910 to date, and serology and roentgenology supply the data for diagnosis.

It is perfectly obvious that even the most complete and detailed history of a supposedly luetic infection may be fallacious. The concurrence of manifestly syphilitic lesions elsewhere does not prove beyond cavil that an associated gastric disorder is also syphilitic. The Wassermann test, though so reliable that it has become a diagnostic mainstay, is not infallible. Accepting a positive Wassermann reaction as proof of a syphilitic infection, it does not necessarily follow that a gastric lesion in the same person is also luetic. Improvement or apparent cure after specific treatment has varying weight depending upon the thoroughness of the clinical, physical and roentgenologic examinations. Microscopic study of tissue from the stomach, unless spirochetes can be demonstrated, is chiefly of value by showing the absence

of malignancy, although the finding of periarteritis and endarteritis has some indicative value for syphilis.

However, the presumption that syphilis may affect any organ in the body, and the increasing number of case-reports of lues gastrica strongly support not only the fact of its existence but also a frequency of occurrence greater than is generally admitted.

Three types of gastric syphilis are distinguished:

1. Simple syphilitic gastritis.
2. Syphilitic ulcer.
3. Syphilitic gummata, hyperplasia, sclerosis or tumor-formation.

According to Cronin,[2] the first case of syphilitic gastritis was reported in 1839 by Andral,[3] who had two cases of chronic gastritis cured by mercury. Rudniew is quoted by Myer[4] as saying that most syphilitics have gastric syphilis, and that in the eruptive stage they have an eruption in the stomach like that on the skin. It is quite possible that the "gastric crises" of tabetics may sometimes be mistaken for an actual gastritis, and with the scant number of case-reports and scantier proof the question of its existence or frequency must be left *sub judice*. The roentgenologist is not directly interested in the condition, for at most the roentgenologic appearances could only be of negative worth by failing to demonstrate organic change.

The occurrence of syphilitic gastric ulcer is well sustained by cases reported. Tuohy[5] suggests that the diagnosis "gastric ulcer" is anatomic, not pathologic, and that perhaps many of these ulcers are of syphilitic origin. Neumann[6] holds that 20 per cent. of the round ulcers occur in syphilitic persons. Fenwick[7] remarks that luetic ulcers are characterized clinically by severity of pain and vomiting, infrequency of hematemesis, resistance to ordinary treatment, and tendency to recurrence. Pathologically, it is noteworthy that in many of the cases published the ulcers were multiple.

Tuohy reports three cases, in one of which (Case 94,732) operation was done at the Mayo Clinic. The case is described in detail. All by the roentgen-ray showed hour-glass con-

traction of the stomach, all had positive Wassermanns, and all improved decisively after antiluetic treatment.

Brugsch and Schneider[8] give a clinical analysis of 106 tertiary luetic patients who had gastric symptoms. In 3 the presence of a tumor was suspected, but it was questionable whether or not the mass was of a gummatous nature. Hypersecretion was noted in 16, achylia in 24, abortive gastric crises in 33, and motor irritability in 18. The motor disturbance was demonstrated by the roentgen-ray in several cases and consisted of hyperperistalsis and spastic contractions. In 13 gastric ulcer was present or strongly suspected. These authors call attention to the frequency of achylia in lues and its common association with luetic gastric ulcer.

McNeil[9] reports an annular syphilitic ulcer almost completely encircling the pylorus, with marked thickening of the region. Microscopically there was extensive periarteritis. No spirochetes could be demonstrated in the sections. After resection and antisyphilitic treatment the patient made a good recovery.

Downes and Le Wald[10] have had 8 cases of syphilis of the stomach in which the diagnosis was established with a fair degree of certainty. The ages of the patients ranged from 14 to 63. Two of the cases were congenital, the others acquired.

The authors state that, histologically, gastric syphilis is characterized by gummata, single or multiple, which start in the submucosa and go on to infiltration, ulceration and cicatrization in varying degrees. Clinically, they note that the symptoms when considered in a general way differ very little from those of other lesions of the stomach of equal extent and like location. However, the pain of a luetic ulcer lacks the periodicity of simple ulcer, is less influenced by food, is often described as of a gnawing character and is persistent. Vomiting was a marked symptom in their cases almost from the beginning. In 3 cases the acids were low and all combined. In 2 the total acidity was higher but with a large proportion of combined acid. Roentgenologically, their findings included deformity and diminution in the size of the stomach, compensatory dilatation of the

esophagus, dumb-bell (hour-glass) stomach, and gaping or obstruction of the pylorus.

The third type of gastric lues, the infiltrative, cirrhotic or tumor-producing type, is of especial interest from the roentgenologic standpoint, since by the roentgen-ray a gumma or a thickening of the gastric wall can be demonstrated with greater certainty than an ulcer. While it is claimed that gummata in the stomach rarely attain large size and soon ulcerate, there is reasonable evidence of at least a few notable exceptions in which the gummatous hyperplasia was extensive. Thus Cronin has collected the cases of Cornil,[11] Birch-Hirschfeld,[12] Einhorn,[13] Faroy[14] and others, in which gummatous infiltrations were found, ranging in breadth from 2 to 20 cm., and having various situations in the stomach. J. S. Myer records 2 cases. One patient, aged 21, had a visible and palpable epigastric tumor "about the size of half an orange," with many clinical evidences of syphilis and a positive Wassermann. Disappearance of the tumor and clinical cure resulted from specific treatment. The other, a man aged 32, at exploration was found to have "a mass as large as a hen's egg on the lesser curvature," adherent everywhere and obstructing the pylorus. After gastro-enterostomy and antiluetic treatment the tumefaction disappeared.

Similar cases, in which roentgenologic observations were also made, are those of Meyers,[15] Holitsch,[16] Christie,[17] Mühlmann,[18] Mills[19] and Morgan.[20]

Meyers' case was a male, aged 22, with a history of syphilitic infection five years previously and positive Wassermann. The gastric symptoms, consisting chiefly of distress after meals, covered a period of seven months, and there was marked weight loss. A palpable mass developed in the epigastrium, and the roentgenogram showed biloculation of the stomach. Treatment resulted in rapid recovery.

The case reported by Holitsch was that of a woman, 33 years of age, with a luetic history and positive Wassermann. For six months she had had pain directly after meals, tenderness in the epigastrium, and loss of weight, but no cachexia. No free

HCl was found in the test meal. The roentgenogram depicted a marked hour-glass contraction. This was confirmed at operation (jejunostomy) and the stomach was found to be shrunken and thick-walled. Microscopic examination of sections from the stomach was negative for tuberculosis or carcinoma. The patient improved under specific treatment, and subsequent roentgenograms showed widening of the stenotic area.

Christie describes a case of syphilitic tumor of the stomach which diminished after treatment with salvarsan, then recurred, as indicated by the roentgen examination.

Mühlmann's case was that of a woman, aged 27, who gave a history of lues, and dyspeptic symptoms, indicative of a contracted stomach with weight loss, positive Wassermann, absence of free HCl, and the suggestion of a palpable, flat, epigastric tumor. The roentgen-ray showed a small stomach without peristalsis, reflux into the esophagus, a gaping pylorus, and local contractions. At operation the stomach was found to be small, shrunken and thick-walled. A portion of the wall excised for microscopic examination showed loss of mucosal epithelium and thickening of the submucosa. Antiluetic treatment after gastro-enterostomy was followed by considerable improvement.

The roentgenogram of Mills' case showed massive filling-defects in the pyloric portion of the stomach, almost obliterating this region. After gastrojejunostomy and specific treatment the gastric shadow was restored. Eusterman[21] who has had a large experience with gastric syphilis reports 40 cases in which lesions were demonstrable, with therapeutic cure or improvement. He says: "All gross syphilitic lesions can be demonstrated by the roentgen examination but small areas of gummatous involvement, or cases of single or multiple ulcers, characteristic in type, and all cases of syphilitic gastritis especially, may easily escape detection."

Morgan reports 8 cases of suspected gastric syphilis. In 6 of these the roentgen examination showed deformity and filling-defects in the stomach at the pyloric end, which in 3 cases disappeared or were greatly diminished after antiluetic treatment.

Brunner[22] abstracts from the literature 13 cases of gastric syphilis in which surgical operations were performed, including resection, gastro-enterostomy and pyloroplasty. He discusses gastric lues from various standpoints.

The symptoms of gastric syphilis are not sufficiently characteristic without laboratory aids to differentiate the condition from other organic or even functional disorders of the stomach. In Eusterman's series of 40 cases pain was present in 39, and was relieved by vomiting in 82.5 per cent. Hemorrhage is a comparatively rare occurrence; it was recorded in only 2 (5 per cent.) of the 40 cases. Practically all cases of gastric syphilis are associated with achylia or rarely with subacid values (80 per cent.). This is an important fact and should always be kept in mind. Absence of tumor mass, cachexia and signs of obstruction were other noteworthy symptoms in these cases.

The pathology of syphilis has been greatly added to by the recent work of Warthin[23] and others. Warthin's investigations have shown that gumma is not the type of lesion of late or latent syphilis. That the viscera are involved in all cases of latent syphilis, not by gummatous processes, but by specific inflammatory processes, eventually fibrosis, is very evident. Warthin noted that the fibrosis in the tissues was very marked and associated with it was infiltration, ulceration and cicatrization in varying degrees. Roentgenology has shown that the gummatous lesion is either rare or gives little or no distress because the majority of cases coming to x-ray examination are not of this type.

Although the roentgen signs of gastric lues are not distinctive and pathognomonic in every case, they furnish decisive evidence of gastric pathology, and, in correlation with the clinical and laboratory findings give indispensable aid in the diagnosis of this disease. From the roentgenologic standpoint, then, the signs of gastric lues are:

1. Filling-defect of the gastric outline, usually without corresponding palpable mass.

2. Hour-glass stomach (dumb-bell) or the upper loculus may be expanded and bulbous, and the lower loculus may be tubular, due to extensive irregular concentric contraction.

3. Six-hour retention less frequent than in other gastric lesions (about 20 per cent.).

4. Diminution of gastric capacity.

5. Stiffening or lessened pliability of the gastric wall.

6. Absence of peristalsis from the involved area.

7. Pylorus free rather than obstructed.

8. Patient usually under cancer age and not ill in proportion to the extent of the disease shown by the x-ray.

9. Absence of a niche, accessory pocket, or typical incisura—classic signs of simple gastric ulcer—were notable in all cases, the only exception being that recorded by Portis.[24]

The study of the cases reported suggests that gastric syphilis is characterized by infiltration and fibrosis and that the gastric ulcers seen are abrasions or shallow erosions of the gastric wall; hence their multiplicity and their failure to show a niche (ulcer crater). Likewise, perforation was not observed in any of our cases. If the filling-defect is associated with a corresponding palpable mass the whole picture is that of cancer, and the examiner will be obliged to make this diagnosis. In lues, however, notwithstanding the extensive distortion of the stomach, no corresponding mass can be felt, and the filling-defects are evidently due not to the intrusion of a tumor, but to an infiltration and contraction of the gastric walls. Therefore, the roentgenologist may be impressed by the discrepancy between the extent of gastric involvement and the general condition of the patient, who is often below the cancer age, is not cachectic, and gives a longer history than that commonly given by cancer patients.

In the diagnosis of cancer and syphilis, there are two other lesions which must be borne in mind; namely, fibromatosis and tuberculosis. Fibromatosis, the "leather-bottle" stomach, is also characterized by chronicity, and the patients maintain a fairly good physical condition for a long time. The roentgen

manifestations of fibromatosis, at least in the cases I have seen, were not different from those of an infiltrative gastric syphilis. Tuberculosis of the stomach usually affects the pyloric end with the production of multiple ulcers and more or less infiltration. Multiple ulcers have also been observed in the ulcerative form of syphilis. While gastric tuberculosis shows definite roentgen evidence of an organic lesion, the character of the process can only be predicated by the exclusion of other lesions.

Obviously, then, an affirmative diagnosis of gastric syphilis requires the earnest coöperation of the clinician and the laboratory worker. As a purely scientific problem, it is beset with doubt and difficulty; as a practical problem, it may often be solved with reasonable certainty by the exercise of ordinary care, and to this every patient is justly entitled. Thus he may sometimes be spared a needless resection of a supposed cancer, or, if operation is necessary, it can be followed up by effective therapy. Among these cases which should be subjected to extraordinarily careful judgment are, (1) those of gastric ulcer with an achlorhydria, (2) those of hour-glass stomach without a niche, (3) the markedly contracted stomachs showing roentgenologic evidence of a gastric lesion which is not typical of either ulcer or cancer, and (4) the cases in which the x-ray findings resemble those of cancer, although they lack the pronounced characteristics, and the patient is under cancer age. In such instances the Wassermann test should not be omitted, and antiluetic therapy should be instituted if the test is positive. This procedure is especially indicated if the gastric lesion is manifestly inoperable. If the lesion is operable, the proof that it is syphilitic should overcome all reasonable doubt, since the patient's right to immediate surgery for a resectable cancer should not be endangered. Thus, on the one hand, the avoidance of a needless operation, and on the other hand, the avoidance of delay of a needed operation should not be overlooked.

The histories of a few cases follow:

Case 92,014, male, aged 33. Neisser at 24. Typhoid at 25. Primary lesion with light secondaries at 26. History of continuous stomach trouble for three years. Sense of fullness and heaviness in epigastrium. Food when swallowed apparently is obstructed at entrance to stomach, and occasions so much discomfort that he vomits, or induces vomiting. For two years has been on strictly liquid diet. Weight loss, 20 pounds. Total acidity 25, all combined; food remnants. Wassermann, total inhibition. Roentgen findings: First examination, September 13, 1913. Retention of one-fourth the

Fig. 167.—Case 92,014. Reflux of the barium meal into the esophagus.

six-hour meal. High hour-glass stomach. Second examination; September 15, 1913 (after belladonna): Organic hour-glass stomach. No palpable mass. Diagnosis: Probable gastric syphilis (Fig. 167). Antiluetic treatment was begun and the patient was reëxamined November 18, 1913, and February 10, 1914. At both these examinations the appearance of the stomach was found to be unchanged, and there was still a small retention from the six-hour meal. The patient went to operation April 25, 1914. Findings at operation: Hour-glass stomach. Multiple ulcers and strictures involving pyloric end and extending well up into body of stomach. The centers of ulceration involve two distinct areas, one shortly above the pylorus, the other in the body of the stomach. The whole stomach is converted into a

thick massive formation of scar-tissue, contracted and typically syphilitic in appearance. The obstruction is extreme. The disease stopped short at the duodenum. The liver contained a number of small areas something like cirrhosis, but not distinct nodules, evidently syphilitic. Resection: End of duodenum implanted into stomach. Pathologist's report: Gastric ulcer. The gross specimen is shown in Fig. 168.

Macroscopically the resected pyloric portion of the stomach presents a smooth uniform mucosa with three small superficial erosions. Gross section shows marked thickening of submucosa and musculature.

FIG. 168 —Gross specimen from Case 92,014.

Microscopic sections: (Figs. 169 and 170) Mucosa atrophic. Submucosa greatly increased in thickness, from connective-tissue hyperplasia. Many blood-vessels of various sizes, with walls hypertrophied and intima destroyed, and considerable round-cell infiltration about them. Musculature twice its normal thickness, with separation of its bundles by old connective tissue rich in blood-vessels and round cells. No evidence of malignancy found.

Subsequent history: Eight months after operation the patient writes that his general condition is improved, but that he is unable to

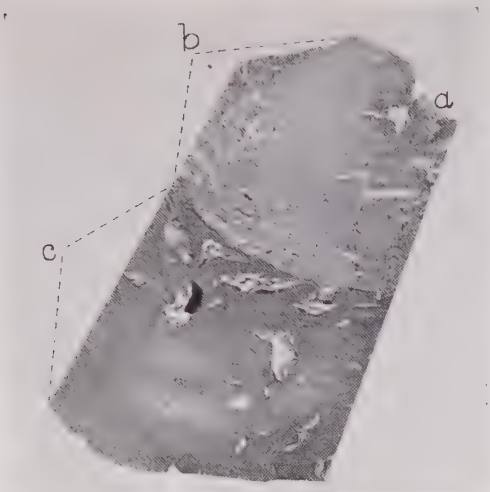

FIG. 169.—Case 92,014. Section of tissue from stomach, 4x. *a*, atrophic mucosa, curling due to fixing solution; *b*, hypertrophied submucosa; *c*, thickened musculature.

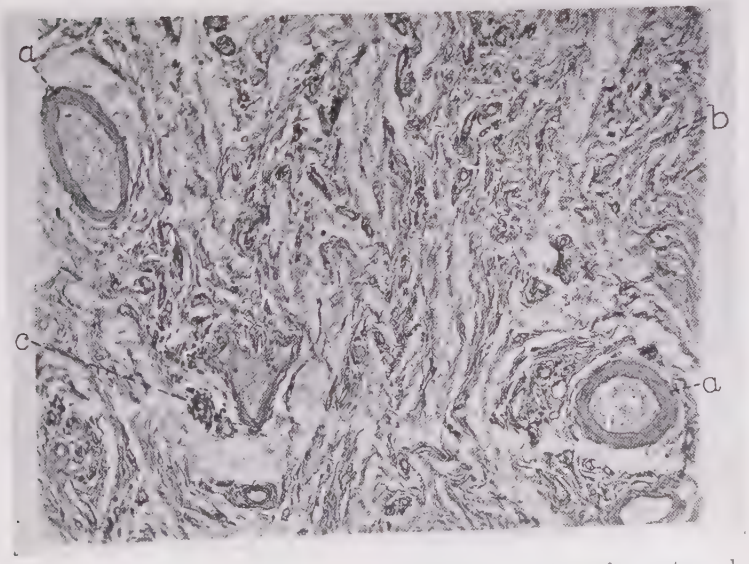

FIG. 170.—Case 92,014. Section microphotograph, 100x, tissue from stomach. *a*, blood vessels with thickened walls; *b*, dense connective tissue; *c*, nest of phagocytes.

eat solid foods without discomfort, and that his weight is still 15 to 20 pounds below normal.

Case 94,732, male, aged 41. Has had Neisser infection and venereal warts. Denies specific infection. About two years ago noticed loss of appetite and then gradual onset of heavy feeling in epigastrium, relieved by vomiting a half to one hour after eating. With this, sour eructations and belching. The first attack lasted three or four months and was succeeded by a free interval of four to six weeks. Since then the trouble has been fairly continuous though worse at times. Belches bitter fluid, mostly at night. Eats only raw eggs and milk now, but

Fig. 171.—Case 94,732

recently even this comes up. Weight loss, 40 pounds. Indefinite feeling of small ridge high in left epigastrium. Rectal shelf free. Hemoglobin 85. Total acids 12, all combined. Wassermann: Negative twice; strong inhibition twice. Roentgen findings: Retention of one-fourth the six-hour meal. Filling-defect with hour-glass contraction at junction of pars media and pars cardiaca. No mass corresponding to defect. The narrowing extends well down to the pyloric portion. Reflux of barium meal into esophagus which is somewhat dilated (Fig. 171). Diagnosis: Carcinoma or syphilis. Findings at operation: Peculiar, ruffled condition pyloric end and body of stomach.

Apparently a series of ulcers on the posterior wall, extending nearly up to the cardia. The stomach is narrowed to size of the wrist. Portion of stomach next to cardia not involved, but too high for gastro-duodenostomy. No glandular involvement but some adhesions posteriorly. Does not seem like carcinoma or simple ulcer; appears rather to be syphilitic. Jejunostomy for feeding purposes. Antiluetic treatment was commenced. Roentgenograms four months after operation showed practically no change in the aspect of the stomach, although the patient had improved greatly in his general condition

Fig. 172.—Case 58,949. First examination.

and had gained 30 pounds. A year after operation the patient states that he is improved, but is still unable to take solids without distress.

Case 58,949, female, aged 27. Married, two children, one miscarriage. Three years ago she developed a lump on the right chest-wall under upper right quadrant of breast. After some nine months this had become a hard fixed tumor, 6 to 10 cm., and projecting 3 to 4 cm. from the chest-wall. This was incised and found to be an abscess. The abscess pocket was excised and necrotic areas of rib curetted. The process recurred repeatedly, was curetted again and again, and finally healed about a year after the use of autogenous vaccines. She now complains of a gastric trouble which began eighteen months ago, consisting of fullness immediately after meals and epigastric pain two

hours after eating. Milk relieves the pain temporarily; other food aggravates. Little weight loss. Patient is anemic. Hemoglobin 85, total acidity 10, all combined. Wassermann, total inhibition. Roentgen findings: First examination May, 1914. The initial clearance was immediate and voluminous; no irregularity of contour; peristalsis normal. Diagnosis negative (Fig. 172).

Second examination July 31, 1914. No retention from the six-hour meal. Gaping pylorus, with narrow, concentrically contracted stomach. No palpable mass corresponding. Evident loss of flexibility. Peristalsis not seen (Fig. 173). Diagnosis: Lesion of stomach.

Fig. 173.—Case 58,949. Second examination, nine weeks after first, no treatment having been given as yet.

The interesting roentgenologic feature of this case is the marked difference between the findings at the two examinations, although only nine weeks had elapsed, and shows how rapidly the process progressed. Treatment: Salvarsan, mercury, iodides. Four months later the patient was much better and was able to eat anything without distress. At the end of a year she writes, complaining only of occasional body-pains. She states that her husband has had a "blood-test" and that he has the same trouble as her own.

Case 81,986, male, aged 41. Neisser infection in youth; no evidence of specific lesion. Almost daily stomach trouble for three years. Fifteen minutes to an hour after meals he had distention, belching, sour eructations, and frequent vomiting. Often colicky pains over mid-abdomen for five to fifteen minutes at any time of day with no relation to food. During the year he had vomiting immediately after or during meals. The vomit might or might not be sour. Diet was not a factor. No dysphagia. Weight loss, 50 pounds. Total

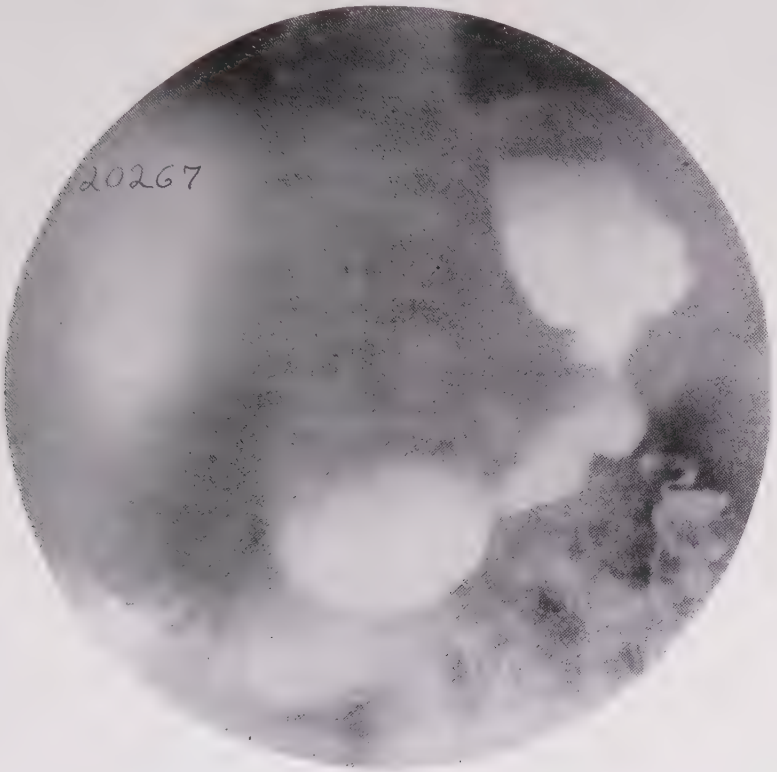

Fig 174.—Case 81,986.

acidity 10, all combined; trace of food remnants. Wassermann strongly positive. Roentgen findings: No retention from the six-hour meal. Gross, markedly irregular concentric filling-defect, involving entire mid-portion of stomach, producing hour-glass stomach. Capacity of stomach reduced. No palpable tumor corresponding to defect. Pylorus gaping. No peristalsis seen in involved area (Fig. 174). Diagnosis: Cancer of the stomach.

Correlated diagnosis (from roentgen, clinical and laboratory findings): Syphilis of stomach. Treatment: Salvarsan, etc.

Subsequent history: Months later the patient could eat a fair meal without distention or vomiting and had gained 20 pounds. Nine months later he was within 5 pounds of his normal weight and his complaints were few and trivial.

Case 141,491, female, aged 30. Married, one miscarriage ten years ago. About six years ago she was treated for syphilis for a year and a half. (This statement was obtained only after the diagnosis had been made.) About eight months ago she began to be troubled

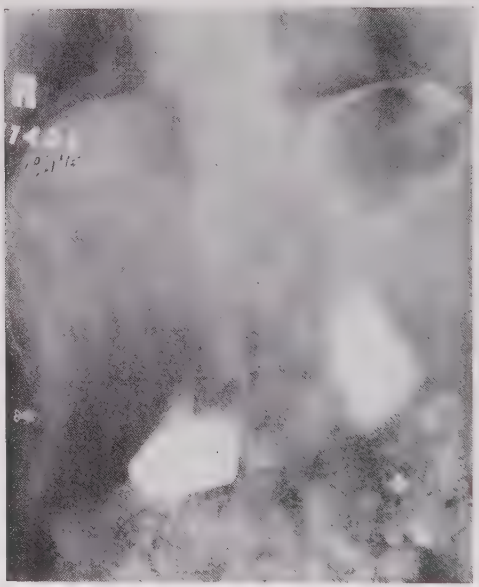

Fig. 175.—Condition of the stomach at the time of examination.

with bloating and bitter regurgitation, aggravated by food. For two months she has taken only infant foods, white of egg, etc. Weight loss, 51 pounds in 6 months. Hemoglobin 80. Total acidity 8, all combined; no food remnants. Wassermann strongly positive. Roentgen findings: Small stomach without retention. Hour-glass contraction pars media. Large filling-defect pyloric end (Fig. 175). Diagnosis: Syphilis or cancer.

The patient was put on antiluetic treatment, salvarsan, mercury inunctions, iodides, with marked improvement clinically and anatomically as shown in the roentgenogram (Fig. 176), made six weeks later. At the end of three months the patient had gained 21 pounds, and was

FIG. 176.—Examination six weeks after antiluetic treatment; marked improvement.

FIG. 177.—Examination at the end of a year revealed a normal stomach.

much stronger. At the end of one year the stomach was normal (Fig. 177).

Case 94,691, male, aged 37. Patient had gonorrhea several years ago. Chancre (?) eight years ago. Wife has had two miscarriages. One child living three months old. Three years ago the patient began having pain and distress in the epigastrium during or immediately after meals, lasting to an hour. This has been continuous since, though less severe at times. Occasional sour eructations and belching. Says skin gets yellowish at times. Stool light in color. Weight

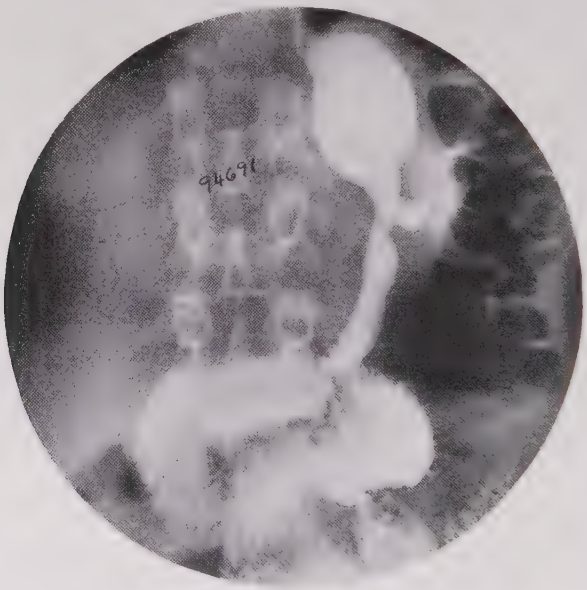

Fig. 178.—Case 94,691.

loss, 45 pounds in three years. He is anemic and emaciated. Skin negative. Tenderness right costal margin. Supraclavicular glands on left enlarged. Hemoglobin 90. Total acidity 4, all combined. Wassermann, total inhibition. Roentgen findings: First examination: No retention from the six-hour meal. The stomach was small, and showed high hour-glass constriction with marked narrowing and irregularity of the pars media and pars pylorica and no corresponding palpable mass. Gaping pylorus (Fig. 178). Diagnosis: Cancer or syphilis of the stomach. Treatment with salvarsan was instituted. Second examination (five weeks later): Condition unchanged. Sixteen months later the patient writes that he has gained 19 pounds in weight, has a good color, and thinks he is still improving.

Case 97,816, male, aged 33. Gonorrhea in youth; now has stricture. Appendectomy and cholecystectomy eight months ago, elsewhere. Five years ago began having attacks of sudden, severe, epigastric pain, that lasted six hours. Intervals free. For a year the pain has been steady, except for a month after operation. It was dull and burning, and worse with a full stomach. Occasional sour regurgitation, and irregular vomiting of bile and food, usually on rising. Weight loss, 26 pounds. Epigastric tenderness and slight resistance. Wassermann, total inhibition. Roentgen findings: First examination,

Fig. 179.—Case 97,816.

December 31, 1913: No retention from the six-hour meal. Filling-defect and hour-glass, involving pars media and pylorica (Fig. 179). No palpable mass. Diagnosis: Ulcer or carcinoma of stomach. A correlation of all the findings indicated the probability of gastric syphilis. Treatment: Salvarsan, mercury, iodides. Second roentgen examination February 2, 1914: Condition unchanged. After two months of treatment without much relief the patient was sent to operation, February 5, 1914. Findings at operation: Syphilitic stomach; lower third involved; very thick-walled condition without limiting margin; adhesions of pylorus and duodenum to liver. Anterior gastro-enterostomy was done. Third roentgen examination February 20, 1914 (fifteen days after operation): Gastro-enterostomy

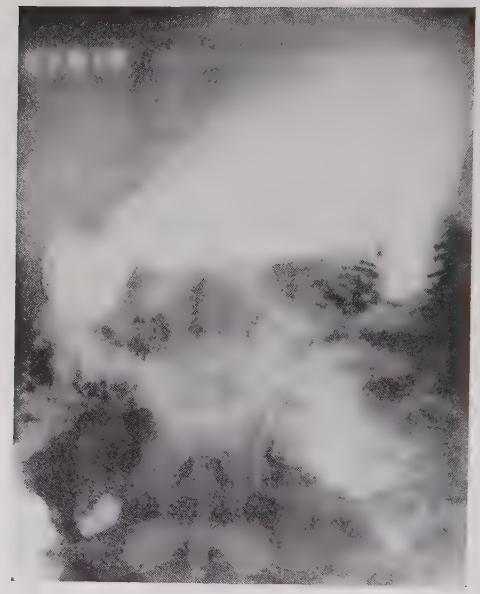

FIG. 180.—Case 97,816.

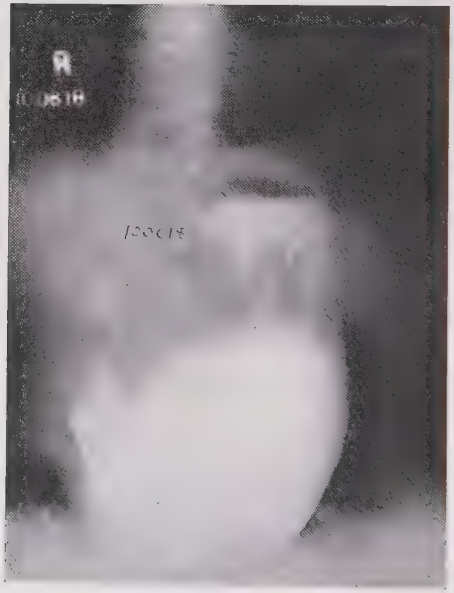

FIG. 181.—Case 100,618.

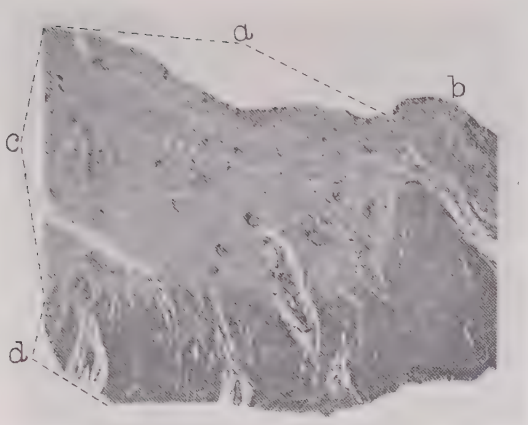

FIG. 182.—Case 100,618. Section of gastric wall, 4x. *a*, floor of ulcer; *b*, intact mucosa; *c*, hypertrophied submucosa; *d*, musculature.

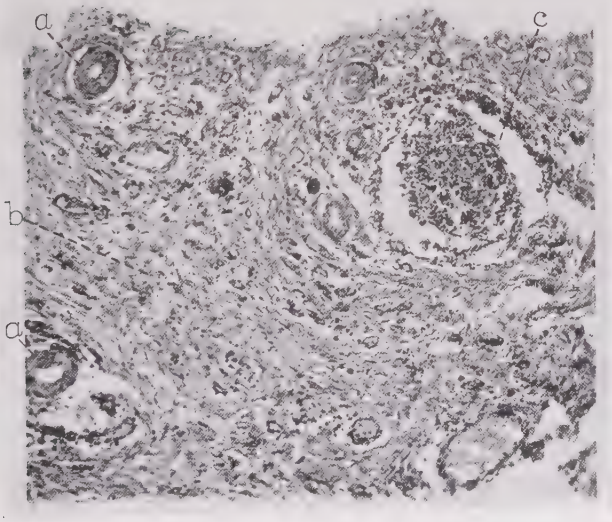

FIG. 183.—Case 100,618. Section of tissue from stomach, 100x. *a*, vessel showing obliterating endarteritis; *b*, dense connective tissue; *c*; mass of phagocytes.

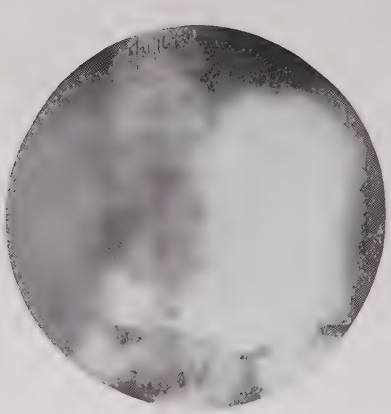

FIG. 184.

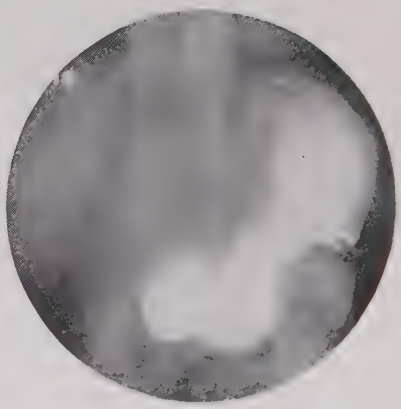

FIG. 185.

FIG. 186.

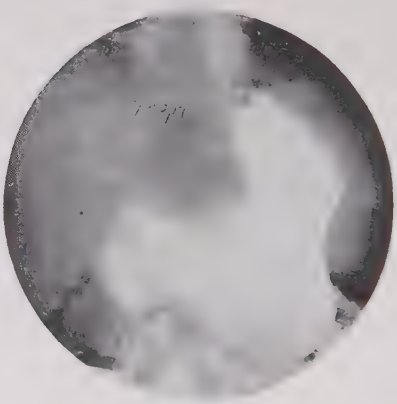

FIG. 187.

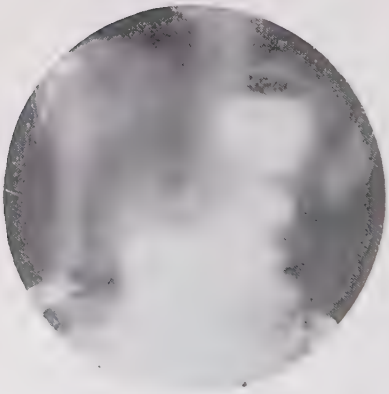

FIG. 188.

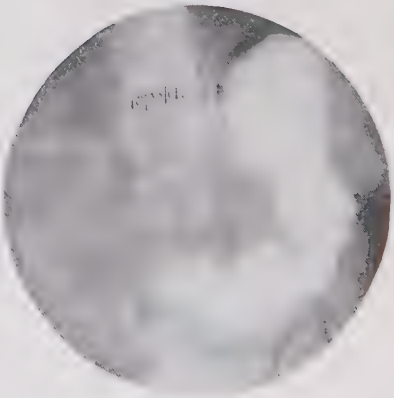

FIG. 189.

FIGS. 184, 185, 186, 187, 188 and 189.—Gastric syphilis.

functionating. Hour-glass more pronounced, the lower segment being almost obliterated (Fig. 180). Eighteen months later the patient returned. He had gained 35 pounds in weight and stated that his stomach was as good as it ever was. Wassermann test nagative.

Case 100,618, male, aged 38; typhoid at 15; gonorrhea at 19. Sixteen years ago, for two years, was addicted to morphine and cocaine; he then took the drug cure and has touched neither since.

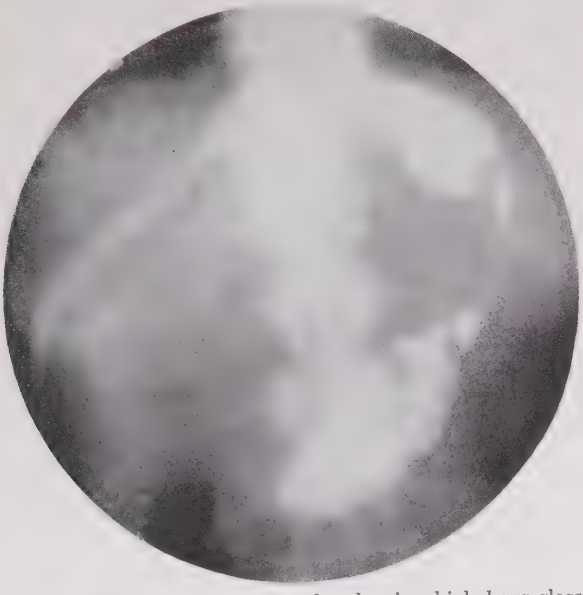

Fig. 190.—Case 145,508. Small stomach, showing high hour-glass constriction. Narrowing and irregularity of the pars media and pars pylorica without corresponding palpable mass. Pylorus gaping. No retention. Reflux of the meal into the esophagus which was moderately dilated.

Two years previously he began having a little epigastric distress a few minutes to an hour after meals. A year before the trouble became much worse and came immediately after meals. For eight months he had had attacks of vomiting every two or three days; vomited blood four weeks ago. Appetite good but afraid to eat because of pain; the latter is eased only by vomiting, sometimes induced. Limited diet six months. Weight-loss, 50 pounds in the past year. Tenderness in epigastrium. Hemoglobin 85. Total acids 12, all combined. Roentgen findings: Large stomach with retention of half the six-hour meal. Prepyloric filling-defect (Fig. 181). No palpable mass. Diagnosis: Prepyloric lesion. Finding at opera-

tion: Ulcer of posterior wall, of the pyloric end of the stomach; precancerous. Resection of stomach. Pathologist's report: Ulcer.

Macroscopically, the resected pyloric end of the stomach shows several small ulcers and a few raised granulomatous areas. On cross-section these areas were distinctly raised. Musculature apparently not hypertrophic.

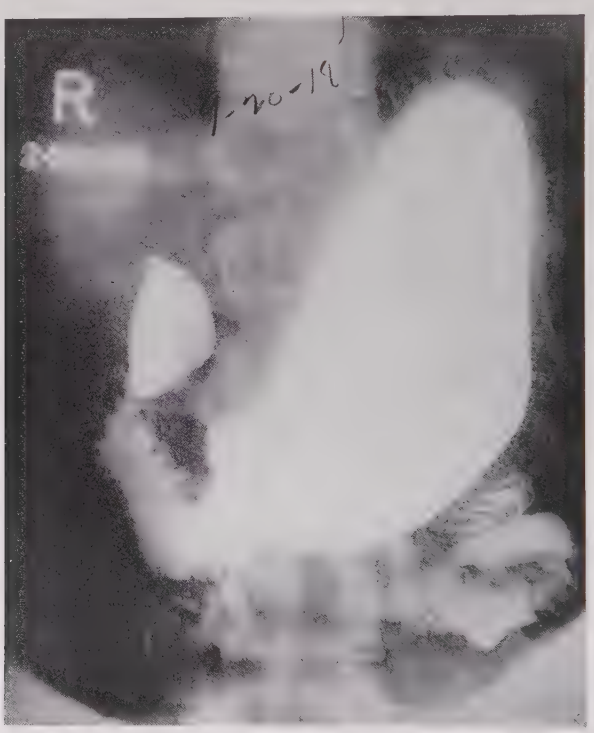

Fig. 191.—Gastric syphilis.

Microscopic section, 4*x*, Fig. 182, shows ulcer area with normal mucosa at border. Marked thickening of submucosa. Musculature thickened little, if any.

Microscopic section, 100*x*, Fig. 183, shows an increase of connective tissue in the submucosa which is many times its normal thickness. Numerous blood-vessels, large and small, with thickening of their walls and destruction of intima. Many blood-vessels are surrounded by nodular collections of large round cells (phagocytes). All sections negative for malignancy. Immediately after his recovery from the operation, a Wassermann test was made and this was found to be

positive. Accordingly, the patient was sent to his home with instructions to take antiluetic treatment by his family physician. Eight months later the patient wrote that he was much improved. No further information has been received.

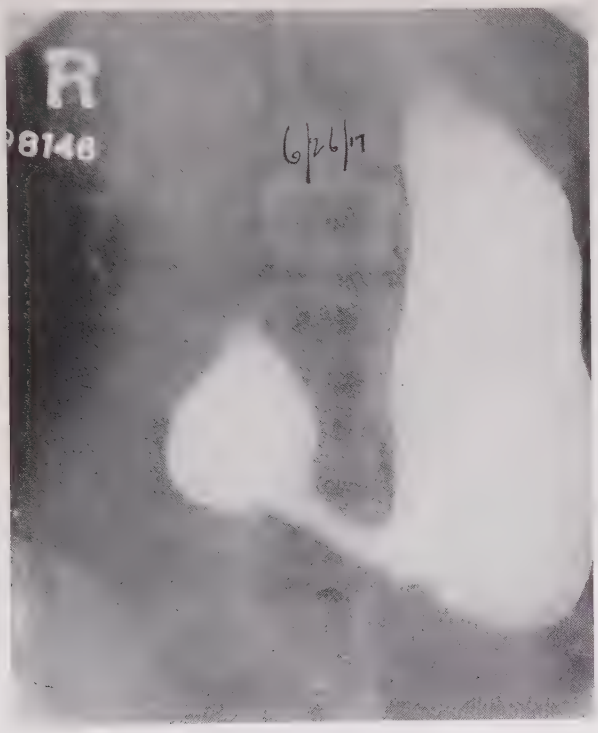

Fig. 192.—Gastric syphilis.

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CHAPTER XII

VARIOUS BENIGN TUMOR-PRODUCING LESIONS OF THE STOMACH

Benign tumors of various kinds, springing from the wall of the stomach, may produce filling-defects in its lumen, and other phenomena which cannot be distinguished roentgenologically from those due to cancer. While not of frequent occurrence, these non-malignant neoplasms have a wide range of histologic variance.

Campbell[1] mentions as among the more important the myomas, fibromas, adenopapillomas and lymphadenomas. Less common, he states, are the myxomas, osteomas, hydatid cysts, serous cysts, blood-cysts and aneurysms. Myomas, fibromas and adenomas are more often found in the pyloric portion of the stomach, and may be single or multiple. Lipomas are usually single and situated on the anterior wall of the pars media.

Wade[2] holds that the majority of benign tumors ultimately come to project within the gastric chamber and become pedunculated, forming polypi. When located near the pylorus they may produce pyloric obstruction by their ball-valve effect. Polypi are often single and may be attached to any part of the gastric mucosa. However, they are sometimes multiple and occasionally so numerous that the term "polyposis" is applicable. Sherren[3] has collected several cases of polypoid tumors attached to the outside of the stomach.

According to Campbell, the only example of dermoid cyst that has heretofore been observed in the stomach, was reported by Ruysch in 1732. It consisted of a small tumor of the gastric wall which contained hair. A case of desmoid, a hard, fibrous tumor, has been published by Gray and Nesselrode.[4]

Nassetti[5] found smooth muscle-tumors in the stomach at

necropsy in 7 instances. He reviewed the similar cases on record, of which he has compiled 140.

Basch[6] gives the usual list of non-malignant gastric neoplasms, and furnishes brief, excellently illustrated histories of 3 cases with the roentgenologic findings. One was a papillary adenoma, the size of a walnut, attached to the lesser curvature near the pylorus. It gave a persistent filling-defect in the roentgenogram. Another was a pedunculated mass about 6 cm. in diameter, attached to the anterior wall, as found at exploration. It produced a spherical central filling-defect at the juncture of the antrum and pars media. On account of the patient's condition it could not be removed, and its exact nature was not determined. In the third case there were two papilloadenomas, one 1.5 cm., the other 4 cm. long, attached to the posterior wall 8 cm. from the pylorus. They produced finger-print-like filling-defects in the screen image and roentgenogram, and were centrally located in the antrum. Hypermotility and hyperperistalsis were also noted.

TUBERCULOSIS OF THE STOMACH

A neoplastic form of tuberculosis of the stomach, more often affecting the pyloric portion, is occasionally noted.

The records of our clinic show that tuberculosis of the stomach has been found once only in a series of about 2500 gastric operations from the years 1912 to 1915 inclusive. This case has been reported in detail by Broders who also reviewed the literature and gave a very complete bibliography.

Case 152,198, F. P., a male, aged 42, bricklayer; married eleven years. One child had died at the age of one year from meningitis. The patient had had no previous diseases; he now complained chiefly of stomach trouble. An exploratory operation had been done six months previously elsewhere and a diagnosis of inoperable carcinoma of the stomach was made; the incision was closed and there was some improvement for five months.

Clinical history: The trouble had begun two years before with a feeling of heaviness in the epigastrium which came on from one-half to two hours after meals. Six months later the patient began to have

attacks of vomiting every two or three days from two to three hours after meals. Nine months before his examination he ceased vomiting for two months but there was no cessation of the epigastric distress. Six months previously there was recurrence of vomiting almost daily, about one-half hour after meals. The patient lost weight rapidly. For the past three weeks regurgitation had occurred as soon as food was taken; eggnog was retained. The patient had never had severe pain or sour stomach; he always felt hungry. A mass in the right side of the upper abdomen was noted. The hemoglobin was 70 per

Fig. 193.—Case 152,198

cent., the erythrocytes were 4,760,000. Test meal showed total acidity 12, all combined; food remnants 1 on a basis of 4; filtrate 150 c.c.; Oppler-Boas 1 on a basis of 4.

Roentgen Report.—The stomach contained a retention of three-fourths of the motor meal at the end of six hours. There was an hour-glass contracture of the stomach in the pars media with some irregularity of contour. The pars pylorica was not visualized (Fig. 193). Operable carcinoma of the stomach was diagnosed. Carcinoma of the stomach was also diagnosed clinically.

Operation.—A Polya resection was done and about one-third of the stomach removed through a high midline incision (E. S. Judd). A tumor of the stomach was found near the pylorus. There was marked spasm but the stomach was not dilated.

Postoperative Laboratory Findings; Macroscopic.—The pyloric third of the stomach contained three yellowish-brown ulcers with ragged edges and dirty rough bases on the mucous surface (Fig. 194). The larger ulcer extended from a point 1.5 cm. from the pyloric ring and upward on the greater curvature for a distance of 7 cm. It was 4 cm. in width. The two smaller ulcers were 1 cm. in diameter. One was situated 2.5 cm. from the pyloric ring and 7 cm. from the large ulcer; the other was 3 cm. from the pyloric ring and 3 cm. from the large ulcer.

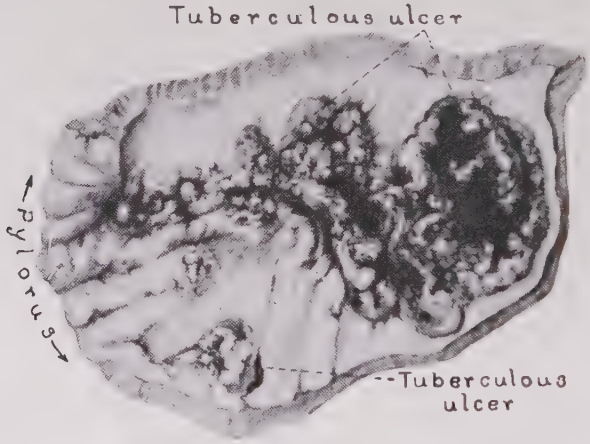

FIG. 194.—(152,198). Photograph of gross specimen.

ANGIOMA OF THE STOMACH

Angioma is a very rare type of gastric tumor producing filling-defects that can hardly be differentiated roentgenologically from those of cancer. The case herein reported (Case 258,233) is the only one that has been seen in the Mayo Clinic.

Lammers[8] reports a case of simple angioma of the stomach found at necropsy, occurring in a man who died of ulcerative endocarditis. Necropsy showed a tumor located on the posterior wall of the stomach about midway between the pylorus and the cardia. It was sharply outlined and projected into the cavity of the stomach in the shape of a spherical mass, 2 cm. across and 1.5 cm. high. From a gross and microscopic study

of specimens Lammers thought the condition could be designated as an angioma simplex, having its origin in the muscularis.

Guisez[9] describes a case of angioma of the cardia. It was found that the lower third of the esophagus was moderately dilated. The cardia opened easily and as its pleats were drawn out, a brownish tumor distorted and resembling a leech filled with blood was seen on the posterior lip of the esophagus. The anterior margin of the tumor, which was about 4 cm. long and almost as large as a thumb, was on the anterior portion of the cardia.

The treatment consisted of dilatation by means of a bougie, and the use of radium. Improvement was very rapid; the patient could soon take food without difficulty and he has continued to do so.

Stockis[10] records a case of congenital capillary angioma in an infant dying on the twelfth day. A small, round bluish-red tumor 16 mm. in diameter and projecting about 5 or 6 mm. was found in the small culdesac of the stomach 1 cm. from the cardia on the posterior wall.

REPORT OF CASE

Case 258,233, a physician aged 67, came to the clinic Jan. 29, 1919, complaining of stomach trouble. During last summer he had had exhausting but not painful diarrhea, with tarry stools. In November pain in the left epigastrium came on, and this troubled him until Christmas time. A milk diet made him worse; he was relieved by the bismuth meal. For the past two weeks he had been conscious of some indefinite epigastric pain which extended into the neighborhood of the gall-bladder, and of much lassitude and fatigue on exertion, which extended to the point of cyanosis and dyspnea. His appetite was good, and food relieved at times. There was no vomit, no hematemesis. Weight loss 25 pounds. The systolic blood pressure was 240; the diastolic blood pressure was 120, the pulse was 72. The left ventricle was hypertrophied; arteriosclerosis was marked. The urinalysis showed albumin and hyaline casts. The gastric analysis showed total acidity 50 and free HCl 30.

Roentgen Findings.—Aneurysm of the descending thoracic aorta. The examination of the colon by clysma was negative. The examina-

tion of the stomach showed it to be normal as to size, shape and position. There was no retention from the six-hour motor meal. An irregular round filling defect about 5 cm. in diameter with no corresponding palpable mass was found (Fig. 195). Diagnosis: Carcinoma of the stomach.

Operative Findings.—A freely movable tumor the size of an orange was found in the body of the stomach. A sleeve resection of the stomach and end-to-end anastomosis were done.

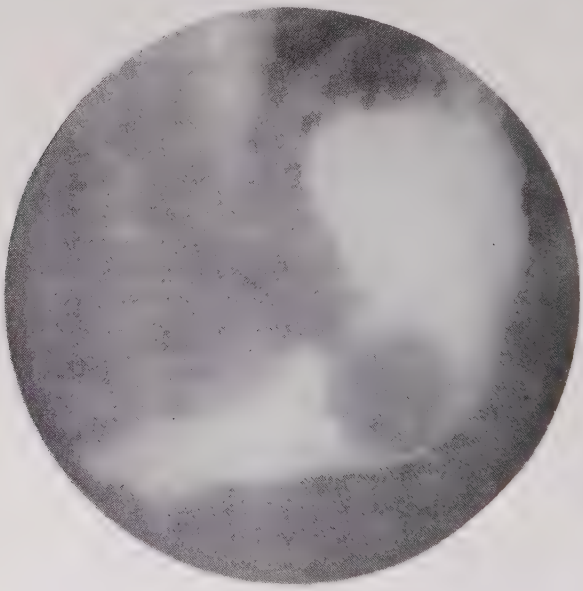

Fig. 195.—Roentgenogram of angioma of the stomach.

Pathologist's Report.—Angioma (5 × 5 × 5 cm.). Note: It is more of a hemangioma, although lymphatic vessels are fairly prominent (Figs. 196 and 197).

Aside from actual neoplasms, the gastric lumen may rarely be intruded upon by varicosities, by a phlegmon in the gastric wall, or by a local hypertrophy of the musculature such as occurs in benign thickening of the pyloric ring. Syphilitic gummata, infiltrations and fibromatosis have been discussed elsewhere.

While all the conditions enumerated should be kept in mind by the roentgenologist as possibilities in cases showing an evident tumor of the stomach, it should equally be remembered

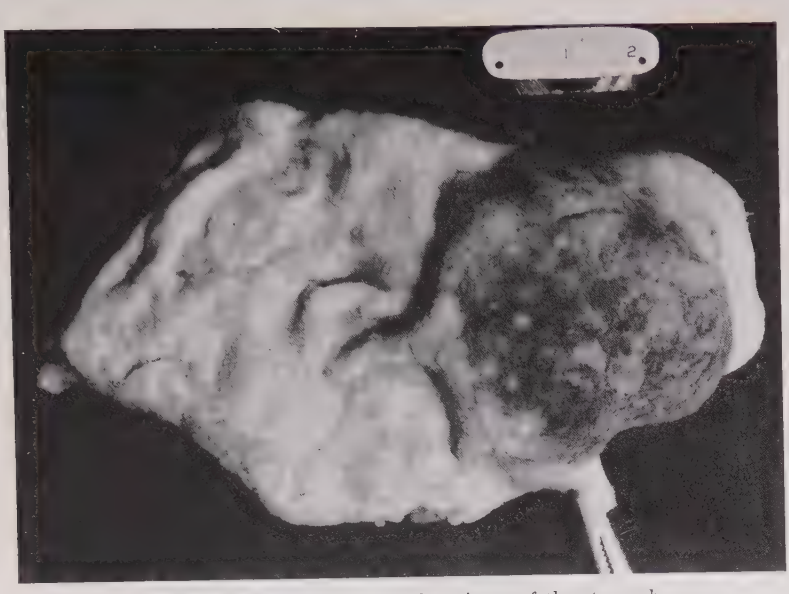

FIG. 196.—Gross specimen of angioma of the stomach.

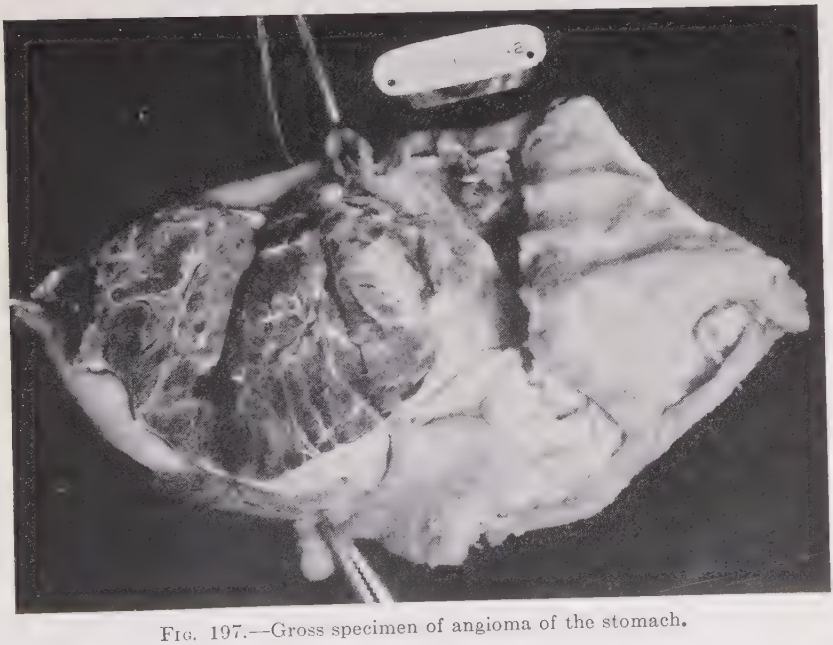

FIG. 197.—Gross specimen of angioma of the stomach.

that the chance of their existence is relatively small. Few of them have been examined by the roentgen-ray, and no general conclusions as to their roentgen manifestations can be drawn from this scant material.

GASTRIC POLYPOSIS

Gastric polyposis is probably the rarest form of benign tumor of the stomach. I have seen but two cases in some fifty thousand examinations of the stomach. Balfour[11] has described in detail the only case seen in the Mayo Clinic.

There is nothing in the clinical history or physical examination of these cases which would establish a diagnosis, or differentiate them from other organic or functional diseases of the stomach. Pain soon after eating was a common symptom in these two cases, due to early emptying time, a result of the achylia which was present in both. In the more advanced case there was hematemesis and a sense of resistance over the pylorus on palpation. Mucus was present in large quantities. It will be noted that these are symptoms and signs that are all found in the more common diseases of the stomach and they are pathognomonic of none.

If any tissue is obtained during gastric lavage this should be examined microscopically; it may give a clue to the lesion, as was demonstrated in the Myer case.

The x-ray then, as shown in these two cases, is the only means at our disposal that is likely to make a probable pre-operative diagnosis. The roentgenograms show a diffuse mottled appearance of the pars pylorica and the lower pars media without six-hour retention or a corresponding palpable mass. This mottling is due to the displacement of the barium by the approximation of the polyps which, offering no resistance to the x-ray, produce numerous small black shadows in the silhouette of the stomach. Since food-bits give a somewhat similar appearance in the barium shadow one should be sure that the patient has had nothing to eat since the day previous.

Case 250,518, a male, aged 31, came to the clinic Nov. 8, 1918, because of "stomach trouble." The patient's trouble began in 1910, with loss of appetite which, during the following five years caused considerable discomfort. A symptom causing great annoyance was pain on an empty stomach first noticed in 1915. This pain begins in the left and right hypochondrium localizing in the epigastrium. It occurs only when the stomach is empty and since the stomach empties rapidly the freedom from pain is very short. It is never associated with burning or other subjective symptoms of hyperacidity.

FIG. 198.—Roentgenogram of gastric polyposis.

By eating at frequent intervals the patient has kept his distress at a minimum and his nutrition practically normal. There had been no nausea, vomiting or evidence of gastric bleeding. The patient had been discharged from the army in 1917 on a diagnosis of pulmonary tuberculosis.

The examination at the clinic gave no evidence of a pulmonary lesion either clinically or by x-ray and the Wassermann test was negative. The gastric test-meal showed an absence of free hydrochloric acid. This fact explained largely the symptoms of which the patient complained, and practically excluded a diagnosis of gastric or duodenal ulcer.

A resection of about two-fifths of the stomach was done and the

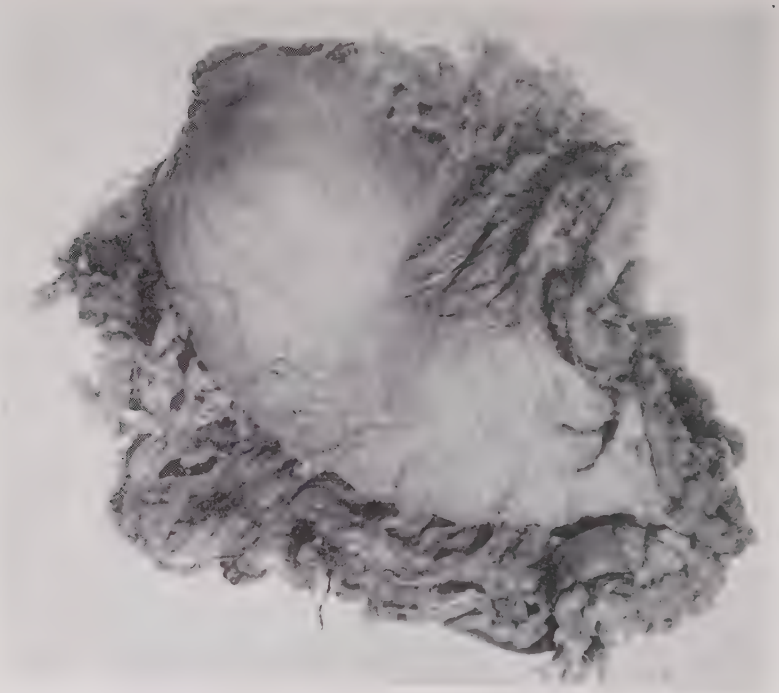

FIG. 199.—Photograph of gross specimen showing the exterior of the stomach.

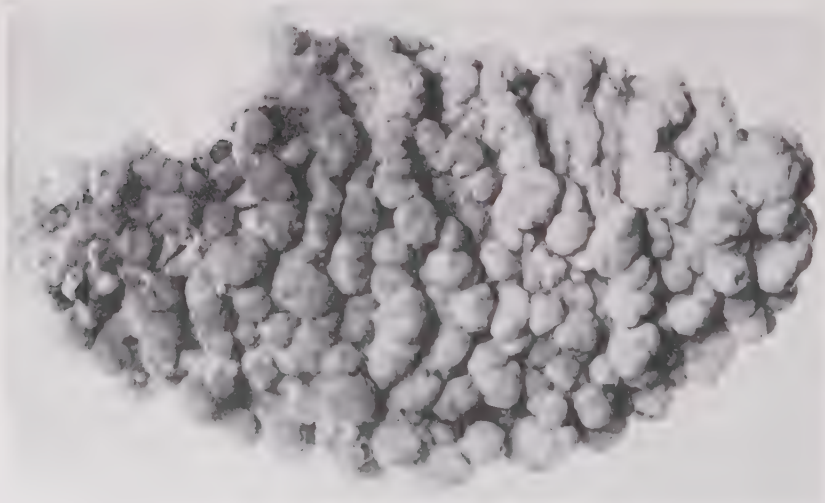

FIG. 200.—Photograph of gross specimen showing gastric mucosa studded with polyps.

patient recovered. On inspection the stomach was found normal in appearance; on palpation it was soft, doughy and thickened, this extended some 12 to 15 cm. above the pylorus. Immediate examination of the tumor by the pathologist showed it to be a typical example of gastric polyposis (Figs. 199 and 200). It was not malignant.

The case of polyposis reported by Myer[12] illustrates both the clinical and roentgenologic aspects of the condition. The observation of this case extended over a period of eight years.

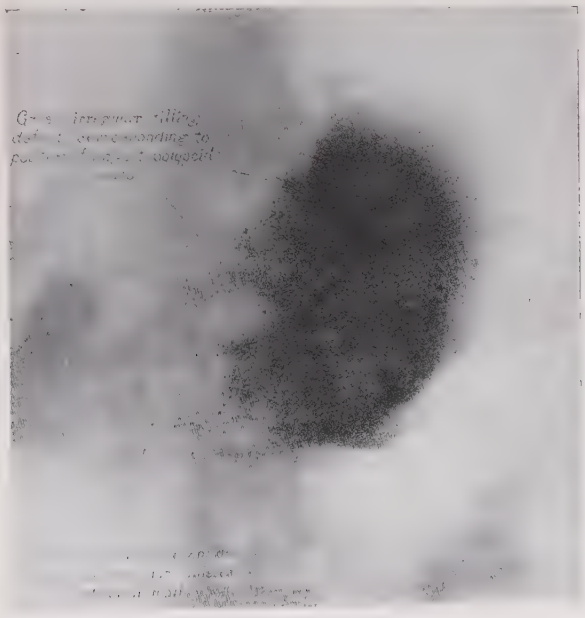

Fig. 201.—Gastric polyposis.

The patient's antecedent history was indicative of syphilis. When seen first in 1904 he was complaining of abdominal distress one or two hours after meals and had lost weight rapidly. Examination of the gastric contents showed achylia, lactic acid and mucus. Subsequently the amount of mucus became extraordinarily large. Five years later, while being subjected to lavage, a polyp "the size of a pea" was expressed through the tube and upon microscopic examination was found to be a simple benign adenoma. In 1912 the patient had severe hema-

temesis. On physical examination, resistance was found over the pylorus and peristalsis was visible.

Fluoroscopic and roentgenographic examinations by the writer revealed an almost total obliteration of the pars pylorica and distal pars media. The main bismuth mass lay to the left of the vertebral column and had an irregular, indefinite con-

FIG. 202.—Gastric polyposis. Photograph of stomach removed postmortem, showing the entire mucosa, with the exception of a small area near the cardiac orifice, literally covered with polyps; *a*, a large grape-like bunch of polyps, a portion of which had invaginated the pylorus.

tour. Small amounts of bismuth trickling through the right half of the stomach gave it a mottled appearance and suggested irregular masses projecting from the gastric wall. The motility of the stomach was not tested by the roentgen method (Fig. 201).

Operation: Gastrotomy. Gastric mucosa literally covered

from the cardia to within 3 cm. of the pylorus with pedicled polyps (Fig. 202). Excision of one large pedunculated papillomatous tumor, "the size of a fist," attached 8 cm. above pylorus. Microscopic section of the polyp showed that its chief mass consisted of hypertrophied mucosa, with immensely hypertrophied glands. Small cysts were noted in various parts of the stomach.

In addition to the foregoing cases, my own experience has included instances of dermoid cyst, fibromyoma and hypertrophy of the pyloric ring. The case histories follow.

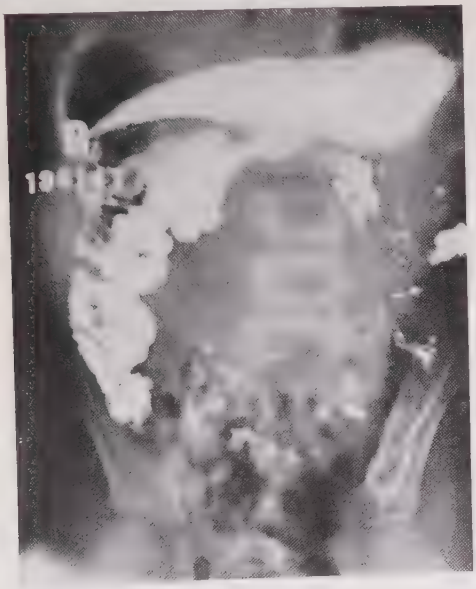

FIG. 203.—Case 136,147.

Case 136,147, boy aged 8. About four years ago the parents noticed a small lump in his abdomen, which seemed to be more prominent at times, especially when standing. The lump has grown gradually and has been quite marked during the past six months. Aside from some urinary frequency, the patient has no symptoms. Hemoglobin 70. Large, freely movable, not tender, mass filling upper and central abdomen. Roentgen findings: No retention from the six-hour meal. Stomach very high, occupying a transverse position. The displacement upward is due to a large palpable tumor which is extrinsic and does not deform the gastric lumen (Fig. 203). Finding at operation:

Gourd-shaped tumor attached to posterior wall of stomach and projecting into the lesser cavity of the peritoneum. Tumor larger than the stomach itself. Resection of area of attachment. Pathologist's report: Dermoid cyst (Fig. 204). Weight 1000 gm.

Case 142,665, female, aged 65. Operation elsewhere four years ago for the removal of gall-stones. Soon afterward she discovered a movable mass in the epigastrium and began to have attacks of sharp epi-

FIG. 204.—Case 136,147. Dermoid cyst.

gastric pain, coming at any time, and vomiting immediately after meals. The present attack has lasted six weeks. Weight loss, 50 pounds in three years. Nodular tumor can be felt in left epigastrium. Hemoglobin 44. Total acidity 6; all combined. Roentgen findings: No retention. Extensive filling-defect involving pars pylorica and media, and part of cardia. Slight hindrance to entrance of barium through esophageal opening (Fig. 205). Diagnosis: Carcinoma; inoperable. (To this report the examiner added the statement that

FIG. 205.—Case 142,665.

FIG. 206.—Case 80,723.

the filling-defect was very unusual.) Findings at operation: Tumor posterior wall of stomach, 8 cm. above pylorus, the size of a small orange. The tumor has invaginated through the pylorus into the duodenum. Exsection of tumor and area of attachment. Pathologist's report: Fibromyoma.

Case 80,723, female, aged 29. Ten years ago she began to have attacks each spring of indigestion, but would be entirely well the rest of the year. Four years ago the trouble became worse; after each meal she would have epigastric burning, vomiting, and gas distention. Food gives relief but is vomited. The attacks last for weeks, with intervals of perfect health. During the past year the pain has frequently been severe and cramp-like, hypodermatic injections being given for relief. Total acidity 30; all free. Epigastric tenderness. Roentgen findings: Retention of half the six-hour meal. Hypotonic, low-lying stomach with strong peristalsis. Prepyloric narrowing seen on the screen. Diagnosis: Pyloric obstruction. The roentgenogram, Fig. 206, does not show the lesion, due to the fact that the plate was made with the patient standing and the barium has settled away from the area involved. The case illustrates the necessity of making at least some of the plates in the prone position. Findings at operation: Great thickening of pylorus, feeling like a tumor. Much thick, ascitic fluid in abdomen. Edematous thickening of upper jejunum with many enlarged glands in mesentery. Resection 10 cm. pyloric end. Anterior gastro-enterostomy. Pathologic report: Hypertrophy of muscular and mucous layers of stomach; 14 mm. at pylorus. Small adenomatous polyp near pylorus. Marked hypertrophy of annular fibers of pylorus, with the opening narrowed to about 5 mm. Glands from mesentery inflammatory.

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CHAPTER XIII

GASTRIC ULCER

The succession of events in developing the roentgenologic diagnosis of gastric ulcer has been orderly, and few steps have been taken which had to be retraced. Even Hemmeter's[1] effort to demonstrate the site of an ulcer by the adherence of a fleck of bismuth was not so far beside the mark. Though impractical in its original application, his employment of an opaque salt and the roentgen-ray had its influence in stimulating others to more successful attempts.

With the advent of the Rieder meal, the Continental roentgenologists were able to find the more striking secondary manifestations of gastric ulcer, notably hour-glass deformity, and gave heed to six-hour retention and other general indications of gastric pathology. Then Reiche succeeded in demonstrating the cavity of an ulcer, and Hemmeter's dream came true. With additional experience it became possible to differentiate secondary gastric phenomena produced by an intrinsic cause from those due to an extrinsic cause, and to combine the former with clinical data into practical syndromes.

The examination of the stomach has become one of the most important developments in x-ray work. Indeed, this fact is so evident that in all doubtful cases the patients should be sent for x-ray examination before they are dismissed. In this agent we have a means of distinguishing double lesions which is hardly possible by the older methods of examination. Besides, many lesions can be discovered earlier than by clinical findings alone.

At its present stage the accuracy of the roentgen diagnosis of gastric ulcer is greater than is generally appreciated, and considerably exceeds that of customary clinical methods. It would seem that in the opinion of some gastro-enterologists the

usefulness of the roentgen-ray in this connection is limited in the main to differentiating gastric from duodenal ulcer. However, they thus unwittingly concede its absolute value in the diagnosis of either condition. We are also obliged to dissent from the assumption that the clinical examination is quite sufficient to confirm or negate the presence of an ulcer, though it may not be able to fix its site.

In roentgen work we encounter three varieties of stomach: The normal, the reflex and the pathologic, and the signs of these must be learned and distinguished from one another. Distinction of the pathologic from the normal is not very difficult, but distinction of the pathologic from the reflex is often troublesome. These reflex manifestations, which are commonly of a spasmodic character, occur frequently in association with disease of the gall-bladder or appendix, and occasionally in neurasthenia, tabes, intoxications, renal calculus and other conditions. They produce the most numerous and most deceptive counterfeits of pathologic signs, and their careful exclusion is always essential.

From our own statistics we can say that nine-tenths of the ulcers of the stomach give distinct roentgenologic indications of gastric disease, and in an overwhelming majority of these the roentgen signs are either pathognomonic or strongly presumptive of ulcer.

As seen at operation, four types of gastric ulcer may be distinguished:

1. Small, exceedingly shallow, mucous erosions and minute slit-like ulcers.

2. Penetrating or perforating ulcers with fairly deep craters.

3. Perforated ulcers, with or without the production of an accessory cavity.

4. Carcinomatous ulcers.

Of these four types, the first—the small, shallow, mucous erosions—offers the greatest difficulty to roentgenologic detection. They are either superficial denudations, or mere slits in the mucosa, incapable of holding enough barium to make a visible projection from the gastric lumen. Unless accompanied

by secondary roentgen signs such as the incisura or the incisura in combination with a six-hour retention, their presence is not likely even to be suspected.

The penetrating ulcers which have burrowed more or less deeply into the gastric wall, produce a definite crater jutting out from the lumen of the stomach. The degree of facility with which this crater can be seen by the roentgen-ray depends more on its location than its size.

Perforation of an ulcer, with a continuation of the destructive process into adjacent tissues, results in the formation of an accessory cavity outside the stomach. Such a cavity can nearly always be seen, both on screen and plate. Perforation may, of course, occur without any excavation of the tissues beyond the stomach. In this event the roentgen-ray should show the ulcer-crater, plus, in some instances, the distorting effect of adhesions.

Early carcinomatous ulcers are not, as a rule, distinguishable from non-malignant ulcers, their roentgenologic signs being the same as those of penetrating and of perforated ulcers.

ROENTGENOLOGIC SIGNS OF GASTRIC ULCER

The roentgen signs of ulcer may be divided into two classes:

1. Primary and practically pathognomonic signs.
   - (*a*) Niche.
   - (*b*) Accessory pocket.
   - (*c*) Organic hour-glass stomach.
2. Secondary and corroborative, but absolutely diagnostic, signs.
   - (*a*) Spastic manifestations.
   - (1) The incisura.
   - (2) Spasmodic hour-glass stomach.
   - (3) Diffuse gastrospasm.
   - (*b*) Retention from the six-hour meal.
   - (*c*) Gastric hypotonus.
   - (*d*) Acute fish-hook form of the stomach.
   - (*e*) Alterations of peristalsis.
   - (*f*) Localized tenderness.
   - (*g*) Lessened mobility of the stomach.

The Niche.—For convenience we shall limit the application of this term to the visualized crater of a penetrating ulcer, the cavity of which lies entirely in the wall of the stomach. The first to show definitely the projection of a bismuth-filled ulcer-crater from the gastric lumen, was Reiche.[2] Later, Haudek[3] called it the "Nischen-symptom" and applied it to every form of recess produced by an ulcer, whether penetrating or perforated.

Fig. 207.—Barium-filled crater of gastric ulcer at *a*.

The niche shows as a bud-like prominence on the peripheral outline of the stomach (Fig. 207). It is often regularly crescentic, but may be irregularly shaped. Its size may vary from a mere fleck to a considerable protuberance. It is worthy of note that a niche may be demonstrable even though the ulcer has not penetrated very deeply (Fig. 208). As an ulcer may occur in any part of the stomach, it follows that the niche may also be found anywhere. By far the larger number, however,

are noted either on the lesser curvature, usually above the incisura angularis, or on the posterior wall near the lesser curvature. When situated on the vertical portion of the lesser curvature, a niche will usually show plainly in the anteroposterior view. If located on the posterior wall of the vertical portion of the stomach, an oblique view is often necessary to discover it. When the niche is seated on the lesser curvature of the pyloric portion, it may be hard to distinguish. Quite

Fig. 208.—Gastric ulcer at *a*. Note that the crater is not deep.

often an ulcer in the pyloric portion is on the posterior wall and detection of the niche is hampered by the difficulty of obtaining any but an anteroposterior view. A small niche in any situation may be hidden or partially obliterated when the stomach is distended, so that careful observation should be made while the stomach is filling, especially while the patient is drinking the aqueous mixture (Fig. 209). The niche accompanies the gastric wall in its movements, whether by palpation or respiration. It fills and empties directly with the stomach.

FIG. 209.—Gastric ulcer with high hour-glass, persistent after belladonna. In this instance a small niche in the plane of the hour-glass constriction was noted at each examination while the patient was drinking the barium-water mixture, but could not be seen after filling the stomach.

FIG. 210.—Accessory cavity due to perforated ulcer at *a*.

A small collection of barium in the bowel adjacent to the gastric outline, especially the lesser curvature, may superficially imitate a niche, but manipulation will readily show the difference. The bulge between two peristaltic waves close together on the lesser curvature often looks very much like a niche. Conversely, a true niche may be mistaken for this bulge. However, as the waves progress, the bulge moves toward the pylorus, while a niche remains stationary, so that a little study of the screen-image will easily make the distinction.

Accessory Pocket.—The accessory pocket, as previously stated, occurs as the result of perforation of an ulcer and extension of the ulcerative process into adjoining structures, producing a cavity (Fig. 210). If situated high up, ulcers of the lesser curvature or anterior wall are apt to perforate against or into the liver, while those lower down and on the posterior wall are more likely to invade the pancreas. Instances have also been noted of perforation between the layers of the lesser omentum, into the anterior abdominal wall, and into the spleen.

I have purposely avoided using the term "diverticulum" generally employed by roentgenologists to describe the cavity formed by a perforated ulcer. In a strict anatomopathologic sense a diverticulum must have the same lining-cells as the viscus from which it springs. Inasmuch as an ulcer begins with destruction of these cells, the production of a diverticulum by an ulcer is hardly possible.

When visualized by the barium meal the contents of the pocket are stratified like those of the stomach; the opaque barium at the bottom has a translucent layer of fluid above it, and this in turn is capped by a small gas-bubble.

Accessory pockets range in diameter from 1 to 5 cm. or more. They are usually spherical in outline, but may be irregularly shaped. A pocket in the liver moves with respiration, while one in the pancreas does not, and the more anterior situation of the former may be shown by an oblique view. If within reach, a pocket is commonly immovable by palpation and tender to pressure. The canal joining it to the gastric cavity may or

may not be distinctly visualized by the barium. Barium remains in the pocket when the gastric contents settle to the lower pole of the stomach, and this feature distinguishes a pocket from a niche.

A six-hour rest in the stomach is often associated with an accessory pocket. Organic hour-glass stomach sometimes accompanies an accessory cavity, but not invariably.

If the stomach is acutely flexed, the beginner may at first mistake a partly filled duodenal bulb for an accessory pocket, and he should be careful to exclude this possibility. A true diverticulum of the stomach, most often a congenital anomaly, might be mistaken for the excavation of an ulcer, either pocket or niche, but this condition is exceedingly rare.

Organic Hour-glass.—Organic hour-glass stomach is an occasional sequence of penetrating or perforated gastric ulcers. The constricted portion is infiltrated or involved in adhesions, and is present at operation. Roentgenologically it cannot be differentiated from the spastic type of hour-glass resulting from ulcer but should be subjected to the same tests as the latter. Like the spastic form it is usually of the B-shape, with a short canal near the lesser curvature (Fig. 216). This serves generally to distinguish it from the cancer hour-glass, which is more often of an x-shape, with a rather long, irregular canal, centrally placed.

Contributory Signs of Ulcer.—To produce either a niche or an accessory pocket it is plainly necessary that the ulcer shall have eroded the gastric wall to a depth sufficient to make a demonstrable projection from the gastric lumen. While this occurs in the majority of the cases examined, there remains a large number of cases in which the ulcer is so shallow that no excavation can be detected. In these, if a roentgen diagnosis can be made at all, it must be based on indirect phenomena.

Spasmodic Manifestations—The Incisura.—Chief among the spasms excited by ulcer and perhaps the strongest contributory sign of this lesion, is the incisura. Exploited early as a practical roentgenologic indication of ulcer, it has been given

abundant attention in the literature, possibly more than it deserves, since it occurs in only a small percentage of cases.

The incisura is an indentation of the gastric wall opposite an ulcer (Fig. 211). Its production is generally believed to be due to irritation of the ulcer, causing a spastic contraction of the circular muscle-fibers in its plane. An incisura may also occur in association with the scar of a healed ulcer. Theoretically, it may occur anywhere in the stomach and be seen on either curvature. However, I have never observed one on the lesser curvature. Practically, the vast majority are found on the greater curvature, and most commonly in the vertical portion of the stomach. Occasionally they may be noted in the pyloric portion (Fig. 212).

Incisuræ have considerable variation as to width and depth. They may be so deep as almost to bisect the stomach, or so shallow as merely to dimple the curvature. The angle of view, of course, affects the apparent depth. The outline of an incisura is commonly sharp and regular, but occasionally some irregularity may be noted. Each of two or more ulcers, even though closely situated, may have its separate incisura.

Recognition of an incisura is not difficult as a rule. The stomach should be watched during the process of filling; after repletion an incisura may be more or less concealed by overlapping of its borders. Overlapping may be so marked that gentle pressure is necessary to visualize the indentation. The patient should be turned about to permit oblique or lateral inspection of the gastric contour. An incisura high up in the vertical portion of the stomach may lie wholly in the fluid zone above the opaque meal and thus escape notice. Occasionally a little barium may settle above the incisura, as upon a shelf, but the incisura will not be clearly visible as such unless the opaque meal surrounds it. Hence the barium should, if necessary, be forced upward by manipulation during the vertical screen-examination, and plates should be made in the prone position. Incisuræ in the pars pylorica are usually small, and this region should be studied closely.

FIG 211 —Incisura at *b*, opposite gastric ulcer *a*.

FIG. 212.—Prepyloric incisura at *a* which was permanent. No visible niche, marked dilatation of first part of duodenum, with irregularity of superior wall at *b*. Diagnosis: Prepyloric ulcer with adhesions obstructing duodenum.

True incisuræ must be differentiated from the normal incisura angularis and incisura cardiaca, from the occasional indentation of the greater curvature where the left costal arch crosses it, from the effect of adhesion-bands, and from spasmodic incisuræ arising from causes outside the stomach.

The normal incisura angularis in the angle of the lesser curvature, and the incisura cardiaca at the juncture of the esophagus with the stomach should be familiar to the roentgenologist. Slightly less familiar is an indrawing of the greater curvature beneath the left costal arch, produced either by the pressure of the arch or by tension of the abdominal muscles. Commonly this indentation is broad, shallow, and obviously not an incisura. However, the depression may be so narrow and sharp that the observer is uncertain. Pushing up the lower pole of the stomach tends to narrow and deepen the indentation and thus add to the uncertainty. In fact, this sort of manipulation may easily produce an apparent incisura in almost any stomach and should be avoided. Palpatory pressure should be directly backward and not upward if an incisura is being sought.

An adhesion-band may constrict the stomach in such fashion as to simulate an incisura. Fig. 213 represents such an instance, the only one that I have encountered.

The most annoying imitations of true incisuræ are those produced by extrinsic spasms, that is to say, spasm excited by causes outside the stomach. Such incisuræ are often associated with disease of the gall-bladder, appendix, or duodenal ulcer. These reflex incisuræ frequently have an appearance and position identical with true incisuræ. They may be stationary or migratory. Their reflex spasmodic character is evident if they move toward the pylorus. Even though stationary, they may be assumed to have an extrinsic cause if they relax and disappear upon massage or after the administration of an antispasmodic. The opinion has been advanced that non-permanent incisuræ may sometimes be caused by shallow erosions but decisive proof of this is lacking as yet.

It follows that a true incisura must be constant and station-

ary, it must be present when the stomach hangs in its natural position, it must survive manipulation, and it must persist after the patient has been given an antispasmodic to physiologic effect.

Spasmodic Hour-glass.—Any stomach which is indented by an incisura may be broadly considered an hour-glass, but unless the constriction is quite deep the term hour-glass is not usually

FIG. 213.—Incisura at *a*, persistent at a second examination after belladonna. Diagnosis: Ulcer of stomach. Operation: No ulcer. Hour-glass due to adhesion-band.

applied. In many instances, however, the local contraction is extreme, the typical character of an incisura is lost, and the hour-glass form is dominant (Fig. 214). The spasmodic hour-glass of gastric ulcer is characterized by a relatively short canal joining the two chambers, the canal being usually near the lesser curvature, thus giving the stomach a B-shape. Spasmodic hour-glass due purely to reflex spasm arising from sources outside the stomach may exactly simulate the hour-glass of ulcer. Therefore, the usual tests should be applied to exclude extrinsic spasm. It must be remembered that the spastic hour-glass of

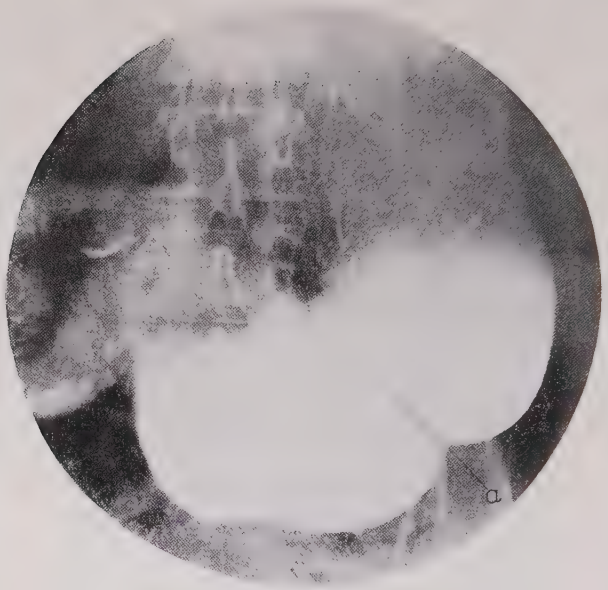

FIG. 214.—Hour-glass stomach. Hour-glass constriction at *a*.

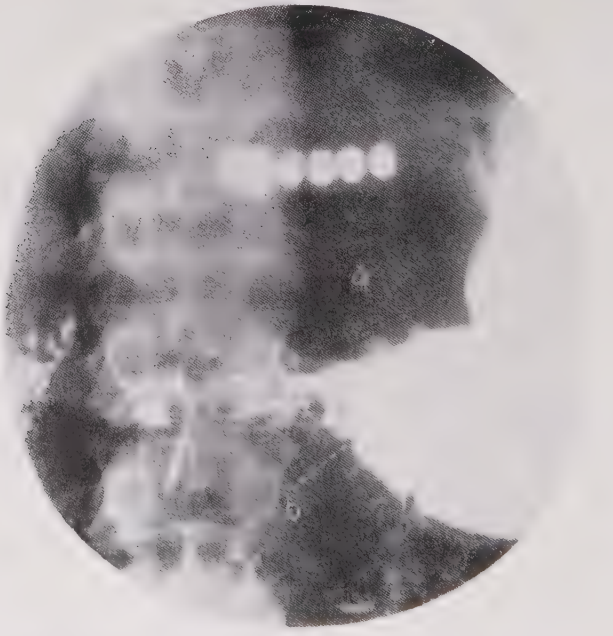

FIG. 215.—Two ulcers shown at *a*. Note prepyloric spasm *b*.

ulcer disappears under general anesthesia, and consequently will not be found by the surgeon.

Other Forms of Spasm.—Besides the localized incisura or spastic hour-glass, gastric ulcer may also give rise to more extensive spasm. Regardless of the situation of the ulcer, this diffuse spasm usually affects the pyloric portion of the stomach,

Fig. 216.—Gastric ulcer with organic hour-glass stomach. Ulcer and constriction at *a*. The lower loculus of the hour-glass is only partly filled, and the canal joining the two loculi is short, although the thin stream of barium trickling down the lesser curvature gives the impression of a long canal.

and the entire pars pylorica may be involved (Fig. 215). On the screen and plate this area is vaguely shadowed, and resembles the filling-defect produced by a prepyloric cancer. The spastic distortion is constant, and cannot be effaced by massage. Since similar spasms may be set up by conditions outside the stomach, these must be excluded if possible.

Differentiation.—Given any of the foregoing varieties of spasm, the examiner's first task is to determine whether they arise from lesions within or without the stomach. Differential characteristics have been discussed at some length in the chapter

on "Gastrospasm." Exclusion of extrinsic spasm by giving belladonna and reëxamining is most important. An incisura, hour-glass or diffuse gastrospasm which is not relaxed by this drug, usually means a lesion of the stomach, most often an ulcer. Among the exceptions, which are not numerous or frequent, are these:

1. Duodenal ulcer occasionally gives rise to a gastric incisura or hour-glass which resists belladonna. In any doubtful case, therefore, a routine examination should be made for duodenal ulcer, in order to confirm or exclude its presence.

2. Exceptionally a small gastric cancer may have an incisura as its sole indication. Such instances are so rare that the examiner is justified in his usual diagnosis of ulcer.

Residue.—A distinct residue in the stomach from the six-hour meal, amounting to an eighth or more of the quantity taken, is a relatively common accompaniment of gastric ulcer. In a series of 215 consecutive cases, I noted a retention in 118 or 55 per cent. Thus gastric ulcer stands a close second to gastric cancer in this respect.

The manner in which an ulcer causes a gastric retention is not definitely known. An ulcer immediately in the pyloric ring, which is relatively uncommon, may cause a narrowing of the ring either by localized spasm or by scar-contraction. But by far the greater number of ulcers are situated at variable distances from the pylorus. The retentions which they produce have been assigned respectively to pylorospasm excited by the ulcer or by an accompanying hyperacidity, to impairment of peristalsis and to the hypotonus which is often associated with ulcer. An extreme type of organic hour-glass due to ulcer may cause a retention in the upper loculus.

A residue in the stomach resulting from an ulcer is sometimes the only definite evidence which the examiner can discover. However, a retention alone is not sufficient for the diagnosis of ulcer, since various causes may operate to produce a six-hour residue. These have been discussed in the chapter on "Abnormal Stomach."

FIG. 217.—Gastric ulcer, immediately prepyloric at *a*. Stomach large and hypotonic.

FIG. 218.—Large hypotonic stomach. One-half the motor meal present at the end of six hours. No organic obstruction at pylorus. Gastric ulcer at *a*.

Gastric Hypotonus.—An evident loss of tone, as shown by sagging and expansion of the lower gastric pole is a frequent accompaniment of ulcer, not only of ulcers causing obstruction (Fig. 217) but occasionally also of ulcers situated rather high in the stomach (Fig. 218). Taken alone, hypotonus possesses little significance, for it is an expected finding in the numerous patients with enteroptotic build. However, if the hypotonus does not accord with the habitus of the patient the possibility of an ulcer should be thought of. In conjunction with other secondary signs, hypotonus has a contributory value, depending on the circumstances.

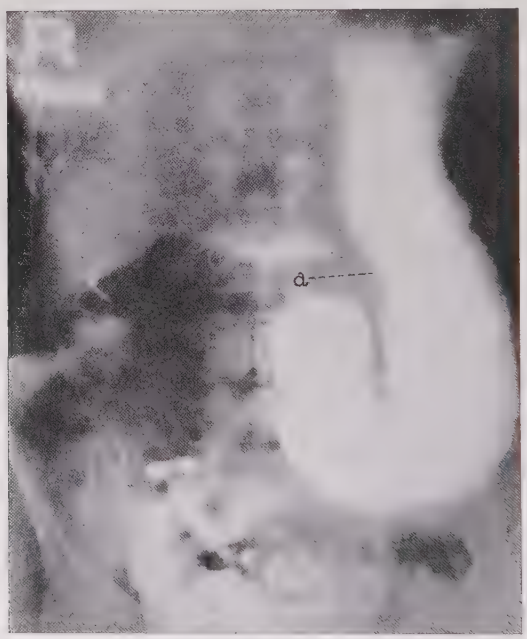

FIG. 219.—Acute fish-hook form of stomach. Ulcer at *a*.

The Acute Fish-hook Stomach.—An acutely flexed, fish-hook form of stomach, with displacement to the left and downward, noted by the older observers as a minor roentgenologic sign of ulcer, has perhaps received more prominence than it merits (Fig. 219). It may occur with or without an ulcer. The snail-

form of Haudek, an extreme degree of flexion due to scar-contraction on the lesser curvature, is of some importance, but corroboration by other signs is necessary for a positive diagnosis.

Abnormalities of Peristalsis.—The variations of peristalsis met with in gastric ulcer include weak peristalsis, hyperperistalsis, especially of irregular type, absence of peristalsis from the ulcer-bearing area and antiperistalsis. None of these is peculiar to ulcer, but all of them are more or less suggestive of a gastric lesion.

Gastric hypotonus is a common accompaniment of gastric ulcer, and hypotonus is usually associated with sluggish peristalsis. An ulcer at the pylorus, producing obstruction, may give rise to vigorous irregular peristalsis, if loss of tone has not followed. Pyloric ulcers, however, are relatively infrequent.

All organic lesions of the gastric wall tend to interfere with peristaltic movement in the area involved. If an ulcer is situated in that portion of the stomach where peristaltic waves are commonly visible, there may be a noticeable local absence of the wave-depression, especially if infiltration about the ulcer is extensive.

Antiperistalsis is occasionally noted with gastric ulcer, most often when six-hour retention is also present. While not necessarily indicative of ulcer, antiperistalsis generally denotes the existence of organic disease either in the stomach or just beyond.

Tender Point.—A sharply localized pressure-tender point over a niche is of confirmatory value. If limited to an area on the curvature opposite an incisura, but without the existence of a niche or accessory pocket, suspicion of an ulcer is increased, nevertheless a diagnostic opinion should be guarded. To be of any value, a pressure-tender point must be narrowly circumscribed, as most persons have more or less tenderness in the epigastrium.

Lessened Mobility.—A local fixation of the gastric wall often results from perforating ulcer with the production of adhesions. However, fixation may ensue from any perigastric inflammation. Besides, satisfactory determination of the actual mobility of the

stomach depends considerably upon its form, tone and position and the relaxation of the abdominal wall. Unless the observer can satisfy himself that definite fixation is present at a certain point, he should not be unduly influenced by what seems to be a lessened mobility of the stomach as a whole.

Value of Sign-groups.—In this analysis I have endeavored to emphasize the niche, the accessory pocket and the organic hour-glass stomach as being the only conclusive roentgen signs of ulcer. The exact worth of the contributory signs enumerated cannot, of course, be stated precisely, yet in various combinations they may sustain a qualified diagnosis of ulcer. Chief among the secondary manifestations are the six-hour residue and the spastic phenomena—incisura, hour-glass and diffuse spasm. When any form of gastrospasm persists after belladonna has been given to physiologic effect, the existence of an intrinsic lesion is fairly proved, and most often the lesion is an ulcer. If a six-hour retention is included in the complex, it is strongly corroborative. Antiperistalsis is also generally indicative of serious pathology. When only secondary signs are found, the conservative roentgenologist will be content with the opinion that a lesion is present. By excluding duodenal ulcer and gastric cancer when possible, and by correlating the roentgen evidence with the clinical and laboratory findings the diagnosis can often be made more specific.

In a series of 139 operative cases of gastric ulcers, 16 (11.5 per cent.) had an associated duodenal ulcer. This frequency of double lesions suggests that the roentgenologist should not be satisfied simply with finding a gastric ulcer but should always carry his investigation to the duodenum. The diagnosis of these lesions when they coexist is, therefore, of some practical value.

A purely clinical diagnosis independent of roentgen assistance is hardly probable. Even when either condition exists alone, clinical distinction of one from the other is often impossible and the x-ray may be the only means of making the differentiation (Fig. 235).

Carcinomatous Ulcer.—The roentgenologic signs of ulcer differ so much from those of carcinoma in the vast majority of cases that differentiation requires no effort. For example, a penetrating ulcer with niche and incisura, or a perforated ulcer with pocket formation bears no roentgenologic resemblance whatever to a well-developed cancer, and patients with only such cancers are likely to come for roentgen examination. In a general way, ulcers project as an addition to the gastric cavity, while cancers encroach on the gastric lumen. Between the typical ulcer and the typical cancer, however, there is a small percentage of cases in which roentgenologic differentiation is difficult or impossible.

Fig. 220.—Large gastric ulcer at *a*; found to be carcinomatous at operation.

An example of this class is the ulcer which on microscopic study shows cancer-cells. Here, the roentgen signs are those of ulcer, and no other diagnosis can usually be offered. At operation the lesion is macroscopically an ulcer, and only microscopic examination can give final judgment. Extreme size of an ulcer-crater, as shown by a very large niche, should make one

suspicious of malignancy, a fact which has been impressed upon me by experience. An ulcer with a niche 3 cm. or more in diameter is likely to prove cancerous (Fig. 220).

In the pyloric region, differentiation of ulcer from cancer is often troublesome. The only roentgenologic signs may be a six-hour rest and an atypical irregularity of contour, and the examiner can only say with certainty that a lesion exists.

A small cancer may have an incisura as its sole index, and the observer will be inclined to suspect ulcer rather than cancer, but this sort of mistake will rarely occur and can hardly be considered a grave error.

As the result of a gross and microscopic study of 445 cancers of the stomach, Wilson and McDowell[4] regard it as probable that gastric cancer develops at the site of a previous ulcerative lesion of the mucosa. While this should not be misconstrued as stating that all ulcers become carcinomatous, it does indicate that many ulcers are potential cancers. Hence, the advantage of an exact diagnosis of gastric ulcer.

It would seem then, that some ulcers of the stomach are malignant. Whether they start as malignant ulcers or change from benign ulcer to cancer, no one knows. Consequently the medical treatment of gastric ulcer on the one hand and procrastination against surgery by the physician and patient on the other, may occasionally deprive the patient of the only chance for cure.

Case 115,292, male, aged 46 years. Trouble with stomach for seven weeks; no prior history, except possibly acid regurgitation after meals during past few years. He now complains of gnawing epigastric pain, worse an hour after meals. There is no definite food-ease, though he feels better immediately after meals, which he attributes to keeping quiet. Water relieves pain for a few minutes; exercise aggravates it. Some pain at night, at different times. Five weeks ago he vomited on frequent occasions one to two hours after meals. No hematemesis. His stools have been continuously black. Weight loss, 10 pounds. Marked epigastric tenderness. Hemoglobin 45. Total acidity 64; free 52; combined 12. Roentgen findings: Retention of one-fourth the motor meal. Niche on lesser curvature, just

FIG. 221.—Case 115,292. Niche of perforated ulcer at *a*.

FIG. 222.—Case 122,649. Gastric ulcer. Very small niche at *a*. Acute fish-hook form of stomach. As will be seen by the pathologist's report, the crater of the ulcer was only 2 millimeters broad. Such an ulcer in an unfavorable situation might easily escape observation.

above incisura angularis (Fig. 221). Diagnosis: Gastric ulcer. Findings at operation: Ulcer of lesser curvature, perforated posteriorly against pancreas, and adherent to it. Gastro-enterostomy.

Case 122,649, female, aged 40 years. Trouble with stomach for fifteen years. The complaint is of two kinds: first, much nausea without vomiting. The nausea is worse before breakfast and is eased by taking food or water. Second, for six years occasional attacks of epigastric pain, radiating to the right costal margin and to the back. The pain comes a half hour after meals and lasts to the next meal, or is relieved a half hour by eating between meals. Relief also by lying down. Never night pain or vomiting. The attacks last for two or three weeks with free intervals of two to three months. Gradual weight loss for twelve years. Hemoglobin 78. Total gastric acidity 38; free 26; combined 12. Roentgen findings: No retention. Small niche on lesser curvature (Fig. 222). Diagnosis: Gastric ulcer. Findings at operation: Small ulcer about the middle of lesser curvature of stomach. Excision. Posterior gastro-enterostomy. Pathologist's report: Ulcer. Crater 2 mm. in diameter.

Case 87,913, male, aged 40 years. Ten year history of trouble with stomach, at first only three or four times a year, but the attacks have increased in duration and frequency. He now complains chiefly of epigastric pain and vomiting. The pain is referred to the right epigastrium, radiates to the back, and comes three or four hours after meals. With the pain there is vomiting of food and sour fluid. On occasions he has noted in the vomit, food taken the day before. After appendectomy two years ago he had no symptoms for six months. Weight loss, 34 pounds in four months. Hemoglobin 68. Total acidity 42, all combined; food remnants. Roentgen findings: Large stomach. Retention of three-fourths the motor meal (Fig. 223). No hour-glass contracture. Accessory pocket just outside lesser curvature (Fig. 224). Peristalsis vigorous. Duodenum not seen during period of examination. Diagnosis: Perforated gastric ulcer. (The hyperperistalsis should have suggested the possibility of a duodenal ulcer to the examiner, but the gastric ulcer being evident, no further examination was made.) Findings at operation: (1) Ulcer of lesser curvature of stomach perforated onto pancreas and transverse colon. (2) Large, hard, obstructing ulcer of the duodenum just below pylorus. Anterior gastro-enterostomy.

Case 30,520, female, aged 30 years. When first seen in the Mayo Clinic in 1909 she had had attacks of pain in the region of the left costal arch for two years. The pain was severe, came several times daily and lasted ten or fifteen minutes each time. Occasionally morphin

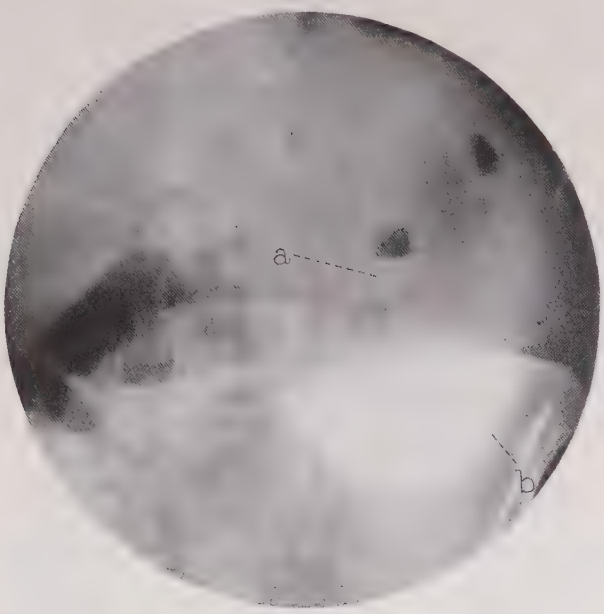

FIG. 223.—Case 87,913. Perforated gastric ulcer. Small six-hour retention in accessory pocket at *a*; with fluid and gas above it. Retention of practically the entire motor meal in stomach, *b*.

FIG. 224.—Case 87,913. Filled stomach, showing accessory pocket outside gastric lumen, *a*.

was required for relief. She returned to the Clinic in January, 1913. Under medical treatment she had been well until the autumn of 1912. Since then she had had daily attacks of pain at the left costal arch, radiating to the back, gradually growing worse, and again requiring morphin. No vomiting, belching or sour eructations. Weight loss, 18 pounds in four months. Total acidity 54; free 50; combined 4; trace of altered blood. Roentgen findings: No retention. Incisura, greater curvature, vertical portion of stomach. This was persistent at a second examination after giving belladonna (Fig. 225). Diagnosis:

Fig. 225.—Case 30,520. Incisura well up on greater curvature at *a*.

Gastric ulcer. Findings at operation: (1) Ulcer 2.5 cm. high on the lesser curvature and posterior wall, firmly adherent to pancreas. (2) Chronic appendicitis. Operation: Excision of ulcer. Appendectomy. Pathologist's report: (1) Simple gastric ulcer. (2) Chronic catarrhal appendicitis.

Case 127,214, female, aged 37 years. For five years past, about once a week, she has had attacks of pain in the left epigastrium radiating between the shoulders. The pain is fairly severe at times, especially with change of weather. It seems to be brought on by eating but may come at any time. Five months ago for a period of two months, she had daily attacks, then a respite until three weeks ago, since when the attacks have been of daily occurrence. She belches gas, and vomits

FIG. 226.—Case 127,214. Organic hour-glass stomach of gastric ulcer at *a*. No visible niche.

FIG. 227.—Case 107,257. Multiple gastric ulcers. Pyloric end puckered and adherent to lesser curvature. Snail form of stomach. Pylorus at *a*.

bitter fluid. Deep inhalation causes pain at the left costal arch. No weight loss. Hemoglobin 80. Total acidity 54; free 40; combined 14. Roentgen findings: No retention. Hour-glass stomach. Reray after belladonna: Hour-glass stomach still present. Tender point corresponding to constricted area (Fig. 226). Diagnosis: Gastric ulcer. Findings at operation: Ulcer on lesser curvature, 12.5 cm. above pylorus. Band producing hour-glass contraction. Gastro-enterostomy.

Case 107,257, female, aged 52 years. For twenty-five years she has had attacks of gnawing epigastric pain, coming a half hour to one hour after meals and continuing for several days or a week, with free intervals of four to six weeks. Nine years ago she vomited a cupful of blood, but did not have severe pain on that occasion. During the past year the pain has been more frequent; sometimes relieved by food and sometimes not. For six months past she has had spells of pain at 11 p.m. Two months ago she again vomited a cupful of blood. Altogether she has vomited rarely. There is much gas and occasional sour eructations. Appendix removed nine years ago. Weight loss slight. Hemoglobin 80. Total acids 10; all combined. Roentgen findings: Retention of half the six-hour meal. Antrum acutely flexed and adherent to lesser curvature. Diagnosis: Lesion of stomach (Fig. 227). Findings at operation: Multiple ulcers causing an acute fish-hook form of stomach, with puckering of the lesser curvature and pylorus. Operation: Finney plastic.

Case 98,523, female, aged 37 years. Starting about 20 years ago, for nine years, from September on through each winter, the patient had attacks of hard, griping, epigastric pain. The pain came an hour after each meal and lasted to the next meal. It was eased by food, soda, rest and change of posture. Thirteen years ago the attacks became shorter but more severe, coming several times a year and lasting two or three weeks with intervals of entire freedom between. The pain has not been accompanied by sour eructations or vomiting. During the past year the attacks have come at short intervals, and on two occasions the pain was so severe as to require morphin. Weight loss slight. Two gastric analyses: (1) Total acidity 36; free 30; combined 6. (2) Total acidity 64; free 54; combined 10. Roentgen findings: First examination, January 10, 1914: Large stomach with retention of half the six-hour meal. Incisura, greater curvature. Second examination, after belladonna: Conditions unchanged (Fig. 228). Diagnosis: Gastric ulcer. Exploration was advised but refused. The patient returned October 22, 1915. At this time a third examination revealed the same conditions as previously, except that a small niche was now visible on the lesser curvature (Fig. 229). Find-

FIG. 228.—Case 98,523. First examination. Large hypotonic stomach with incisura at *a*.

FIG. 229.—Case 98,523. Second examination. Niche at *a*; hour-glass constriction at *b*.

ings at operation: (1) Ulcer very high on lesser curvature, with semblance of hour-glass. (2) Stones in gall-bladder. Cautery excision of ulcer; gastro-enterostomy. Cholecystectomy. Pathologist's report: Chronic catarrhal cholecystitis; cholelithiasis.

Case 94,543, female, aged 28 years. For six years attacks of pain in the left epigastrium coming two or three hours after meals and accompanied by vomiting and lasting from one to four weeks. She vomited blood six years ago and again three years ago. Recently she was in bed for several days with incessant vomiting. The pain radiates to the left shoulder and at times requires codeine for relief. No definite food-ease, but she states that she has less pain immediately after meals. Little loss of weight. Hemoglobin 70. Total acidity 60; free 52; combined 8; food remnants definite. Roentgen findings: Large stomach with retention of three-fourths of the motor meal. Niche on lesser curvature seen on oblique view only (Fig. 230). Incisura opposite on greater curvature, of irregular type. Diagnosis: Gastric ulcer. Figs. 231, 232, 233, 234. Findings at operation: (1) Ulcer on the lesser curvature at incisura angularis, and a contact ulcer on the posterior wall, causing hour-glass stomach. Ulcer very adherent to liver and pancreas. (2) Ulcer of duodenum, anterior wall, moderately obstructive. Operation: (1) Sleeve-resection of stomach. (2) Excision duodenal ulcer; Finney pyloroplasty. Pathologist's report: Multiple simple ulcers of stomach (Fig. 234). Post-operative roentgen findings: Five weeks after operation: Very small stomach with contraction on greater curvature at site of sleeve resection (Fig. 232). Four and one-half months after operation: Stomach shows marked increase in size (Fig. 233). One year after operation: Retention of one-fourth the motor meal. Contracture still present at site of resection. Stomach still larger in size.

Case 150,820, female, aged 66 years. Intermittent gastric disturbances for the past 12 years; food distress rather than food-ease; epigastric soreness, more marked on the left side. Patient says she is nauseated most of the time and vomits often without effort or relief. For years unable to lie on left side, because of nausea. No bleeding. Always light eater; lived on pint of milk and cream daily for years. In the past six months she has been progressively worse. Soreness left side, no desire for food, because of nausea and vomiting. Weight early 125 pounds, two years ago 103 pounds, now 99 pounds. Total acidity 34, free HCl 28; combined 6. Hemoglobin 88 per cent.; reds 4,624,000. Roentgen findings: Stomach large, with a number two retention at the end of six hours. Small six-hour retention in the duodenum. Peristalsis vigorous and of irregular type. Niche, pre-

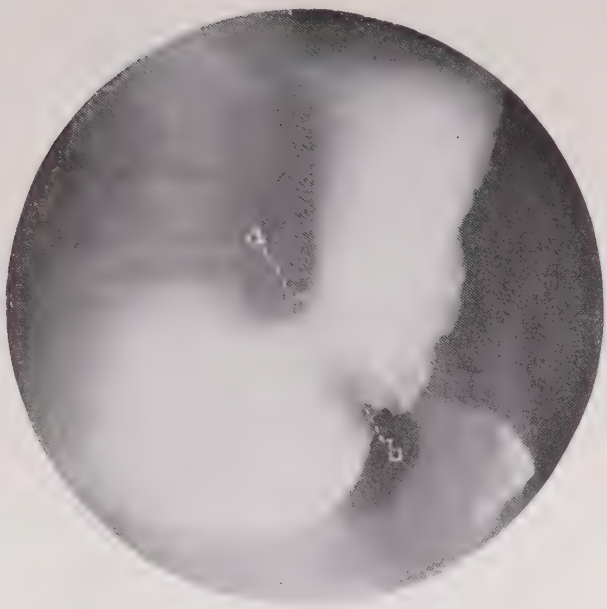

FIG. 230.—Case 94,543. Oblique view. Niche, *a*, on lesser curvature. Wavy incisura at *b*.

FIG. 231.—Case 94,543. Dorso-ventral view. Suggestion of a double incisura on greater curvature. No niche seen on lesser curvature.

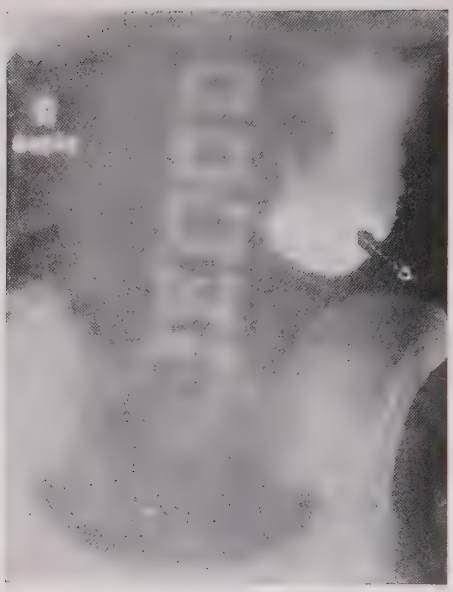

FIG. 232.—Case 94,543. Stomach soon after sleeve-resection. Note small size of stomach and the contraction, *a*, at suture-line.

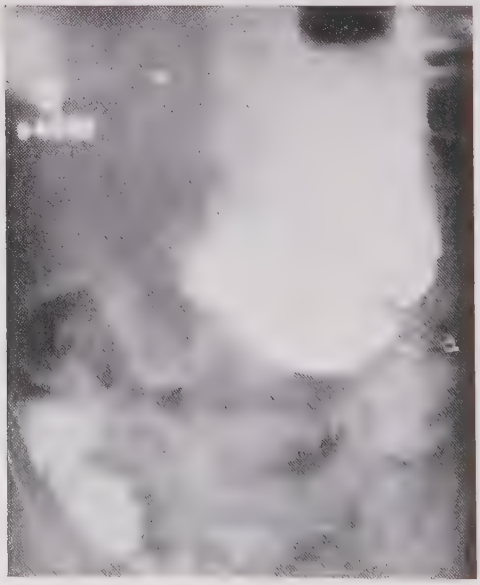

FIG. 233 —Case 94,543. Stomach approximating normal capacity a few months after operation. Contraction, *a*, at suture-line still present.

pyloric, lesser curvature. Cap deformity (Fig. 235). Diagnosis: Gastric ulcer; duodenal ulcer. Operative findings: Double ulcer: Ulcer of the stomach 7.5 cm. above the pylorus on lesser curvature. Ulcer duodenum extending up to pyloric ring. Operation: 1. Cautery excision gastric ulcer. 2. Pylorus blocked by two silk mattress sutures. 3. Posterior gastro-enterostomy.

Case 135,028, male, aged 37 years. Trouble with stomach one year, almost continuous, never well more than two or three days in succession. Burning epigastric pain, two to three hours after meals,

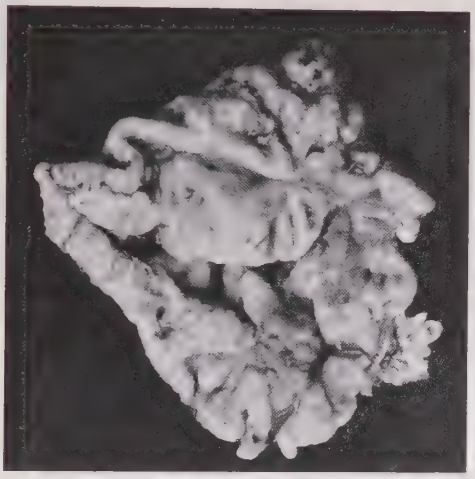

FIG. 234.—Case 94,543. Photograph of resected specimen, showing multiple ulcers and puckered areas of healed ulcers.

and at 10 p.m. Relief by soda; partial food relief. Belching and water-brash. Vomited once, ten months ago; some blood. No vomiting since. Feels best with stomach entirely empty. Some loss of weight. Hemoglobin 90. Two gastric analyses: (1) Total acidity 32; free 24; combined 8. (2) Total acidity 50; free 36; combined 14. Roentgen findings: Screen and plate examination negative (Fig. 236). Findings at operation: Ulcer on lesser curvature of the stomach, high up near cardiac end. Operation: Cauterization of ulcer. Posterior gastro-enterostomy.

Case 139,094, female, aged 47 years. For twenty years she has had attacks of "heartburn" with some pain in the stomach about three times a week. This has been getting more frequent and now occurs about one hour after each meal. Acids and baked potatoes cause most discomfort; milk and crackers least. The attacks last several hours;

relief by soda. She is free from distress in the intervals. There is much gas, bloating and belching, and frequent sour eructations, but never vomiting. Normal weight 100; present 76. Hemoglobin 35. Firm mass, dull to percussion 1 inch to right of mid-line, extending from costal margin to 1 inch below the level of the umbilicus and 4 inches to the left of mid-line. Total acidity 46; free 30; combined 16; altered blood. Wassermann negative. Roentgen findings: Retention

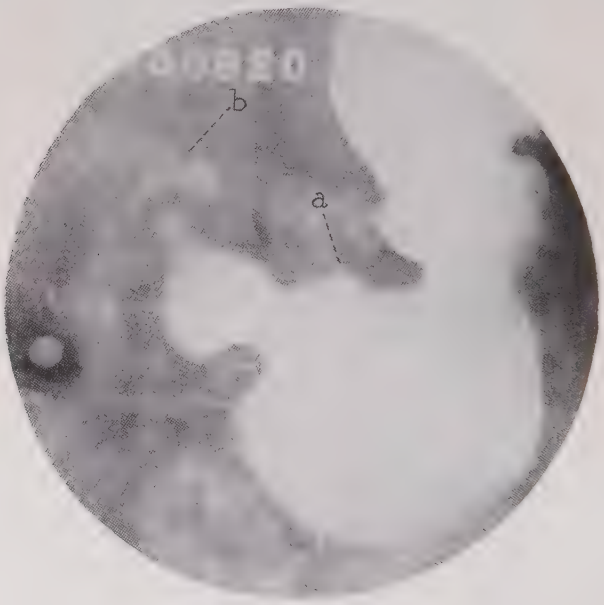

Fig. 235.—Case 150,820. Niche of gastric ulcer at *a*. Spastic deformity of duodenal bulb at *b*, constant at screen-examination and on all plates. The spasm was intrinsic and due to duodenal ulcer.

of three-fourths of the six-hour meal. Hour-glass stomach. Large perforated ulcer, on the lesser curvature, of the mid-portion of stomach (Fig. 237). Patient died one week after the examination. Post-mortem findings: The stomach is filled with a fibrinous clot. There is a carcinoma which has developed on a large saddle ulcer which has perforated against the pancreas. At one point in the base of the ulcer, the origin of the hemorrhage, which occurred from an artery in the pancreas, can be seen. The edges of the carcinomatous ulcer are thickened and calloused.

Case 151,968, male, aged 59 years. Gastric trouble for the last five or six years. Present trouble began six months ago, and has been more or less continuous. Gastric symptoms consist of dull epigastric

FIG. 236.—Case 135,028. Gastric ulcer, lesser curvature, high up in cardia. Screen and plate findings negative. Plates made with patient prone.

FIG. 237.—Case 139,094. Large perforated ulcer at *a*. Hour-glass contracture at *b*.

pain coming on soon after meals with soda-ease. Much gas, sour eructations, occasional heartburn and water-brash. Vomiting is a prominent feature since onset, coming on from one-half to three hours after meals. Never has been any food-ease, patient always feeling better when stomach is empty. Usual weight 155 pounds, now 139 pounds. Hemoglobin 85 per cent.; reds 5,200,000. Total acidity 26; free HCl 0; combined 26. Wassermann negative. Roentgen findings: Large stomach with retention of three-fourths of the

Fig. 238.—Case 151,968. Niche high on lesser curvature at *a*.

motor meal. Small niche high on the lesser curvature. Peristalsis of vigorous irregular type. Practically no barium seen passing from stomach into the duodenum. Diagnosis gastric ulcer; obstruction just beyond pylorus (Fig. 238). Operative findings: Small ulcer high on the lesser curvature. Ulcer duodenum producing obstruction. Duodenum was completely sealed against the gall-bladder. Empyema of the gall-bladder which was filled with stones. Gall-bladder had perforated into duodenum, producing a fistulous tract between. Operation: (1) Cautery excision, ulcer of stomach. (2) Posterior gastroenterostomy. (3) Cholecystectomy. (4) Closure of fistulous tract between gall-bladder and duodenum. Pathologist's report: Gall-bladder with stones, chronic cholecystitis.

FIG. 239.

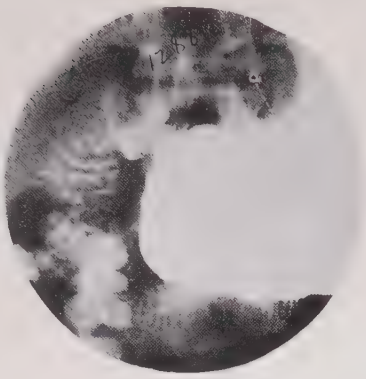

FIG. 240.

FIG. 241

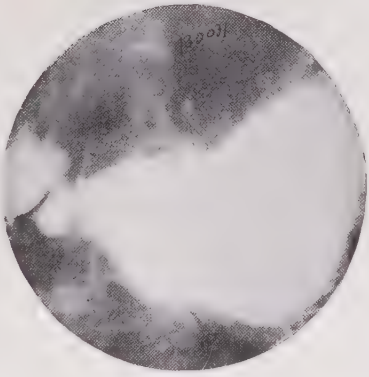

FIG. 242.

FIGS. 239, 240, 241, 242.—Gastric ulcers with niches of various sizes and situations. The niche is shown at *a*.

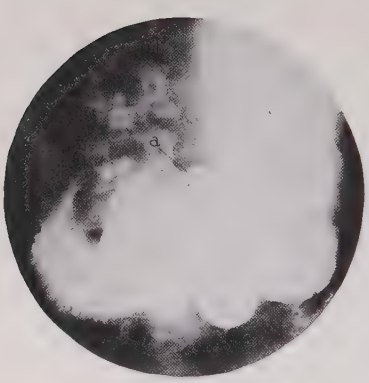

FIG. 243.

FIG. 244.

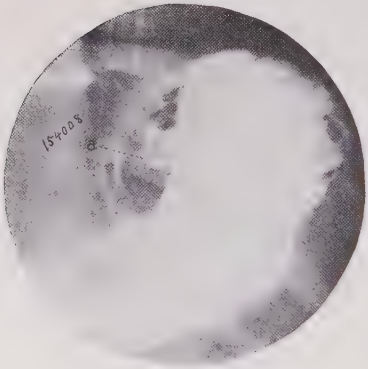

FIG 245.

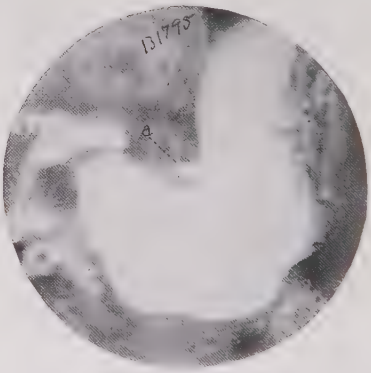

FIG. 246.

FIGS. 243, 244, 245, 246.—Gastric ulcers with niches of various sizes and situations. The niche is shown at *a*.

FIG. 247.

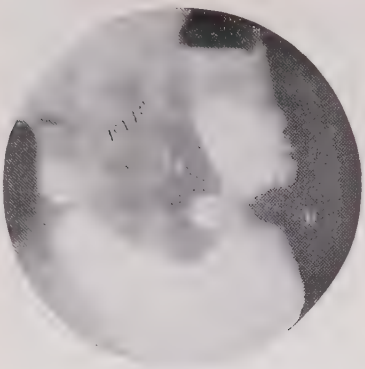

FIG. 248.

FIG. 249.

FIG. 250.

FIGS. 247, 248, 249, 250.—Perforated gastric ulcers with accessory pockets, with and without hour-glass contracture. Accessory pocket, *a*. Hour-glass constriction, *b*.

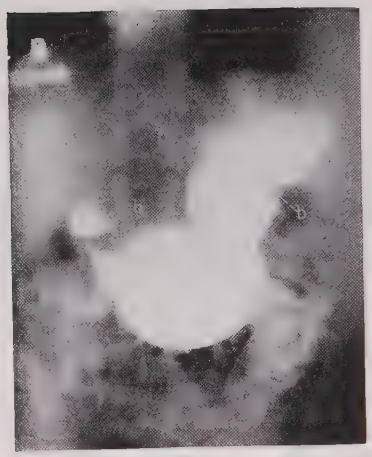

FIG. 251.

FIG. 252.

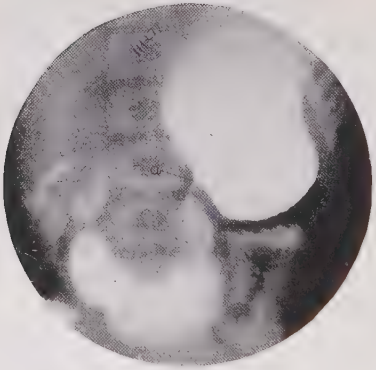

FIG. 253.

FIG. 254.

FIGS. 251, 252, 253, 254.—Gastric ulcers producing organic hour-glass contracture.. No visible niche.

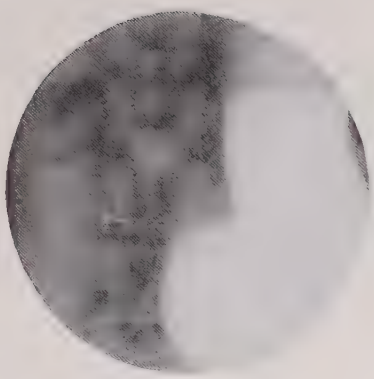

Fig. 255.

Fig. 256.

Fig. 257.

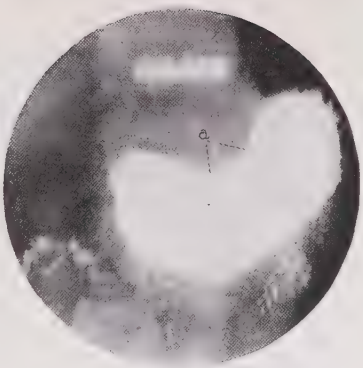

Fig. 258.

Fig. 255.—No niche, no evidence of any indurated area. Barium excluded from prepyloric region at *a*. There was also a retention of one-fourth the motor meal. At operation a small slit-like ulcer was found on the lesser curvature, body of stomach. See Fig. 256

Fig. 256.—Photograph of specimen from case shown in Fig. 255. The minuteness and shallowness of the ulcer explain the absence of a visible niche.

Fig. 257.—Prepyloric irregularity at *a*. Diagnosis: Prepyloric lesion. At operation, gastric ulcer, just above pylorus, posterior wall.

Fig. 258.—Large shallow niche of a saddle ulcer at *a*. Such a niche might easily be mistaken for the bulge between two peristaltic waves.

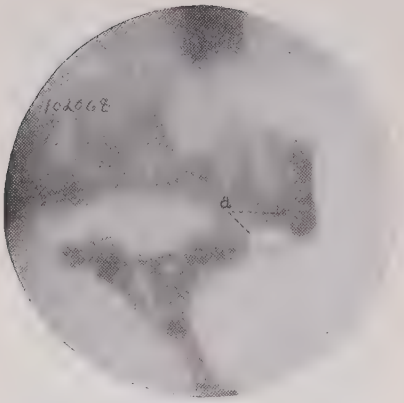

Fig. 259.—Accessory pocket of perforated ulcer at *a*. Oblique view. Perforation against pancreas. See specimen, Fig. 260.

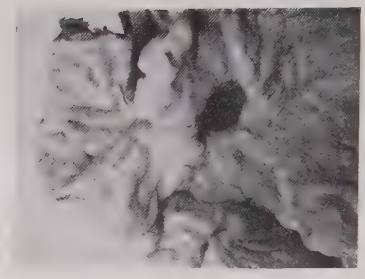

Fig. 260.—Photograph of specimen showing cavity of ulcer.

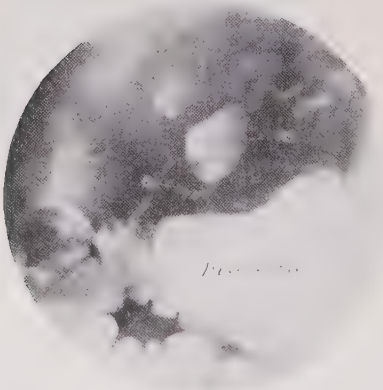

Fig. 261.—Gastric ulcer near pylorus, producing irregularity and obstruction at *a*. Shadow of gallstone at *b*. Barium in duodenum, *c*.

Fig. 262.—Photograph of section from stomach showing crater of penetrating ulcer at *c*.

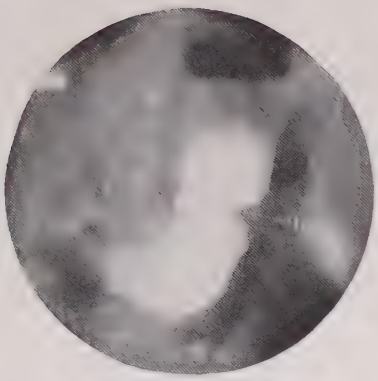

FIG. 263.—Gastric ulcer. Niche at *a*. Incisura at *b*. Resected specimen shown in Fig. 264.

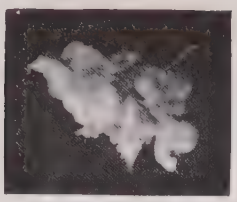

FIG. 264.—Photograph of ulcer resected from stomach. Crater of ulcer at *c*.

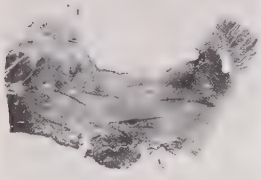

FIG. 265.—Photomicrograph, 4x, of cross section through an ulcer. The destruction extends to the musculature, but not into it. The excavation, *c*, is the niche seen in the roentgenogram, Fig. 263.

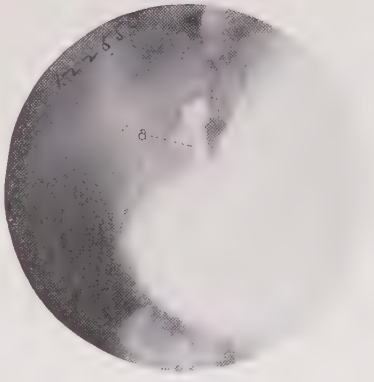

FIG. 266.—Large stomach with retention of half the six-hour meal. Prepyloric narrowing at *a*. Diagnosis: Obstructive lesion on gastric side of pyloric ring. At operation: Fairly large ulcer high on lesser curvature. (The diagnosis was based wholly on the secondary signs. The prepyloric narrowing was due to spasm).

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CHAPTER XIV

ROENTGENOLOGIC ASPECTS OF HOUR-GLASS STOMACH

The ease with which deformity of the gastric contour can be detected has resulted in a greatly increased number of correct diagnoses of hour-glass stomach. But, as might be expected, it may also happen that after the radiologist has made a confident report and stated that hour-glass is present, the operating surgeon will occasionally find that such is not the case, and it is for this reason that some surgeons have been inclined to question the value of roentgen findings in the diagnosis of this deformity.

In order to clear up misunderstandings with regard to such findings it seems timely to review the subject at some length, even though a few facts may be repeated that are well known to the initiated.

While hour-glass deformity of the stomach is admittedly not a disease entity, it possesses more or less distinctive pathologic importance and, were there no other reason, its striking title alone would give it a special interest in medical literature.

Accurately speaking, the hour-glass stomach is simply an occasional end-result of various gastric lesions, but the nature of this end-result materially affects the symptomatology, diagnosis, and treatment of the causative disease. With the development of roentgen diagnosis the detection of this deformity has become far less difficult than formerly, and the subject is, therefore, of particular moment to the radiologist.

The term "hour-glass" defines itself, but the term is applied to every stomach with a locally constricted lumen anywhere between the pylorus and the cardia, whether this is due to organic change, to spasm, or to both.

It is the intention here to deal with the subject chiefly from

the roentgenologic standpoint, which necessitates a brief preliminary discussion of the etiology and pathology.

As to etiology, the time-honored classification of hour-glass stomach into congenital and acquired can hardly be discarded, even though the existence of the former is doubted by some. Notwithstanding the cases reported and the supporting theoretical arguments offered, congenital hour-glass stomach is a rare condition, and it is this extreme rarity that makes the subject of little practical interest especially to the radiologist who can hardly differentiate between these two types.

In a general way, acquired hour-glass stomach may be grouped into two classes, organic and spasmodic.

FIG. 267.—(203,205). Organic hour-glass stomach in a case of inoperable gastric cancer Confirmed by necropsy.

In the organic type the constriction is due to permanent structural changes either in or about the gastric wall. The stenosis thus produced is often increased by spasm of the circular muscle fibers, but regardless of this fact the condition is essentially organic and permanent (Fig. 267).

Gastric ulcer, either of the perforated or penetrating type, stands first in the etiology. By perforating against an adjacent organ, most often the pancreas or the liver, the stomach is not

only fixed at that point but the resulting adhesions may involve a considerable portion of the neighboring gastric periphery. Following this fixation and local transverse contraction, the weight of the food probably tends to produce a sagging of the loculi, exaggerating the proportional narrowing of the isthmus. When the ulcerative process, without an immediate sealing off as sometimes occurs, continues to excavate the tissues outside the stomach, resulting in an accessory pocket, it is fre-

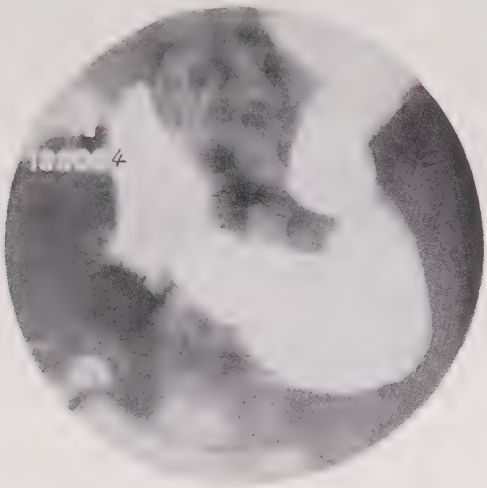

FIG. 268.—(139,094). Organic hour-glass stomach due to perforated gastric ulcer with accessory pocket.

quently but not invariably associated with hour-glass stomach (Fig. 268). Though less often than the perforated variety, penetrating ulcers may also produce hour-glass constriction by infiltration and cicatricial contraction. The ulcers that give rise to hour-glass contraction are most often situated on the lesser curvature, less frequently on the posterior wall, and in either event, usually in the middle of the stomach. Generally the constriction occurs at the expense of the greater curvature which is drawn sharply toward the lesser curvature, while the latter holds its usual position. The indentation of the greater curvature is, as a rule, relatively narrow, and results in a correspondingly short isthmus along the lesser curvature, which

gives the deformed stomach a semblance to the capital letter B (Fig. 269).

There are occasional striking exceptions: An ulcer on the greater curvature may be accompanied by an indrawing of the lesser curvature; an ulcer in any situation may contract the walls of the stomach in the plane of its site; the isthmus, instead of being short, may be relatively long. The width of the canal is, of course, variable, but even when it is quite narrow, the

FIG. 269.—(157,751). Organic hour-glass stomach in a case of gastric ulcer. The deformity gives the stomach the form of a capital letter B.

constriction is nearly always sufficiently emphatic to be readily noted.

Gastric syphilis, which is more often recognized now than it was in the past, probably ranks second to simple ulcer in producing hour-glass stomach (Fig. 270).

Gastric cancer, as a causative factor in hour-glass stomach, probably ranks next in importance; but this has been found to be an accompaniment in less than 1 per cent. of the cases. The cancer may be of the annular type, encircling and constricting the gastric circumference; or, if localized at either curvature on the anterior or posterior wall, it may produce contraction of that segment of the stomach. Again, a cancer mass pro-

jecting into the lumen of the stomach may divide it into two chambers. Sarcomas or benign growths may cause a similar biloculation, but such tumors are not of common occurrence.

FIG. 270.—(173,711). High organic hour-glass stomach in a case of gastric syphilis. The Wassermann test was positive.

FIG. 271.—(152,198). Organic hour-glass stomach in a case of gastric tuberculosis. Postmortem confirmation.

A hyperplastic form of tuberculosis is occasionally found in the stomach; the process involves the pyloric end of the stomach

without hour-glass deformity. However, tuberculous ulcers, which are often multiple and located in the body of the stomach, may constrict this portion (Fig. 271).

More or less contraction may ensue following certain operations, notably gastrostomy, gastro-enterostomy, sleeve resection or local excision of gastric lesions (Fig. 272). After gastrostomy or sleeve resection the contraction may be fairly pronounced, but after gastro-enterostomy there is usually no

FIG. 272.—(94,543). Spasmodic hour-glass constriction following sleeve resection for multiple gastric ulcers. Contracture at point of anastomosis.

constriction unless a gastrojejunal ulcer develops or extensive adhesions form (Figs. 273 and 274).

Hour-glass contraction has resulted from scarring due to corrosive chemicals, such as muriatic acid, as in a case reported by Klein.[1]

Perigastric inflammatory processes of various kinds may produce bands or adhesions and cause hour-glass deformity. Occasionally the hour-glass condition is found to be caused by a single adhesion band of unknown origin. In Elder's[2] case the stomach was drawn up by a ligamentous band from the right rectus muscle. Mayo Robson[3] mentions an instance in which the stomach was trilocular, one constriction (the proximal)

FIG. 273.—(191,809). Spasmodic hour-glass constriction following sleeve resection. The narrowing is at the point of anastomosis.

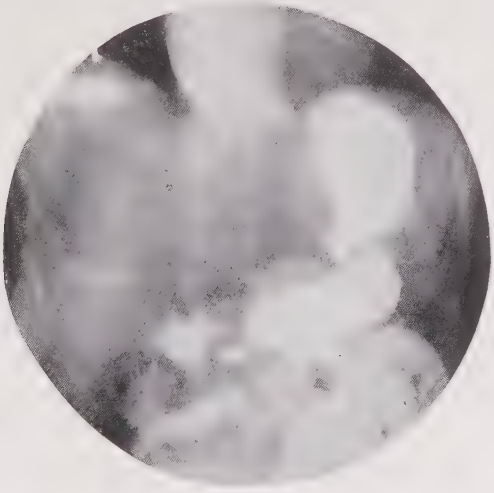

FIG. 274.—(191,830). Spasmodic hour-glass stomach after gastrostomy, done 18 years ago in a case of cardiospasm.

being caused by a band of adhesions from the liver to the transverse colon, while the other was due to the cicatrization of a chronic ulcer.

Conflicting statements have been made as to the relative size of the two pockets in organic hour-glass, particularly the common form due to ulcer. Tuffier and Roux-Berger[4] generally found the narrowing to be nearer the pylorus than the cardia; hence the upper pouch was the larger. On the other hand, Eusterman[5] found the lower loculus to be the larger in a considerable series of cases. The x-ray examination of the cases in the Mayo Clinic for six years past indicate that in the majority of instances the upper pocket was the larger, but this discordance in observations is rather immaterial. Moynihan[6] has found that the proximal portion has thicker walls than the pyloric portion and is larger by reason of dilatation and hypertrophy.

Among the complications of organic hour-glass, volvulus has been observed by Hermes[7] and by Reinecke.[8] In Hermes' case the hour-glass constriction was the size of a finger. The pyloric loculus had rotated on its long axis, protruding through a slit in the mesocolon. In Reinecke's case, also, there was a volvulus of the pyloric segment, causing complete stenosis at the hour-glass constriction.

Referring to spasmodic hour-glass stomach, the rôle played by spasm in the production of this condition has become better understood with the increasing employment of the roentgen examination. Surgeons have sometimes noted peculiar spastic manifestations in the stomach during operation. For example, W. J. Mayo, while operating, has on several occasions seen spasms in which the stomach slowly contracted, the gastric wall became thick and blanched, and then as slowly relaxed again. But the significance of this spasm was not appreciated until the roentgen-ray and the opaque meal came into common use. One of the earliest discoveries was the fact that the barium-filled stomach sometimes showed a spasm of the circular muscle-fibers in the plane of gastric ulcer, thus producing an indentation on the opposite curvature, the incisura. Later, more diffuse

forms of spasm were recognized and the whole subject of gastrospasm became an important chapter in gastric radiology.

The causes of spasm producing hour-glass stomach may be classified as *intrinsic* and *extrinsic*.

Intrinsic spasm is a convenient designation for spastic contraction of the gastric musculature arising directly from a lesion of the stomach itself. In the majority of cases the lesion is an ulcer, and most often the circular fibers chiefly are affected (Fig. 275). When the stomach is filled with barium, the spasm

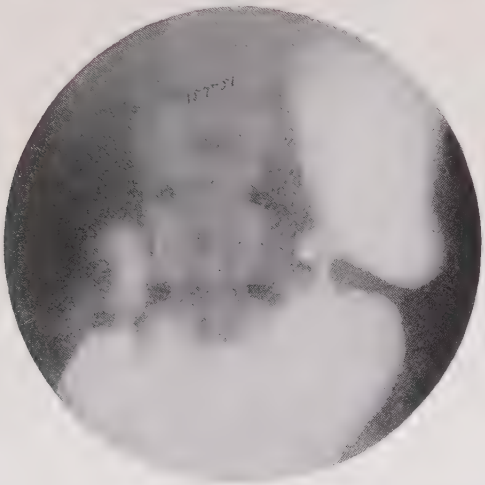

FIG. 275.—(197,546). Spasmodic hour-glass stomach.

is roentgenologically observed opposite the ulcer as a local indrawing of the curvature, commonly the greater. It is in this form that the indentation may be relatively slight in some cases or so deep in others as almost to bisect the stomach. Cancer may also produce a similar local spastic indrawing of the gastric wall, and spasm is probably accountable in some cases for the hour-glass contraction accompanying tuberculous and syphilitic lesions.

The view has been expressed by Moynihan and by Reizenstein[9] and Frei that in many cases of organic hour-glass stomach the narrowing is exaggerated by spasm. This is unquestionably true.

Extrinsic spasm is either produced by lesions outside the stomach or is at all events accompanied by such lesions. It is an occasional cause of hour-glass deformity, as seen roentgenologically, and has been noted in association with duodenal ulcer, disease of the gall-bladder or appendix, and sometimes in hysterical or other nervous manifestations.

The purely spastic hour-glass deformity, whether intrinsic or extrinsic in origin, is rarely present at operation because of the relaxation produced by narcosis, and for this reason the roentgenologist is sometimes wrongfully accused of an error in diagnosis.

As to symptoms and signs, the clinical literature of hour-glass stomach is almost exclusively devoted to the organic form. Agreement is general that the symptoms alone are not diagnostic. They may point rather definitely to ulcer, the most common causative lesion, but seldom suggest the complicating factor. In a few of the cases reported as congenital it is noteworthy that the patients, although adults, gave only a recent history of gastric disturbance.

On the other hand, the physical signs of the condition have been given considerable emphasis. Moynihan holds that these signs, in conjunction with the symptoms, enable a positive diagnosis to be made in the greater number of cases. Mayo Robson says: "While in nearly all cases the cause has been capable of diagnosis, the effect has also been diagnosed in some, and may be in nearly all cases if care and time be given the diagnosis."

Tuffier states that the importance of the clinical signs has diminished with the use of the roentgen-ray. However, he sounds a warning to the effect that in spite of its precision a roentgenologic examination for hour-glass stomach may lead to error.

Notwithstanding the opinion of Mayo Robson and Moynihan that a positive diagnosis is possible in most cases, it is noteworthy that neither they nor others report many cases as having been diagnosed clinically before operation, while it is obvious that the x-ray affords a practical and efficient means of diagnosis.

X-RAY DIAGNOSIS

Since the essential feature of an hour-glass stomach is its biloculation by an intermediate constriction, it would seem that the choice of roentgenologic methods to demonstrate this fact is not important. It is conceivable that the x-ray examination may show the biloculation more or less positively after air inflation. However, by filling the stomach with an opaque meal, the deformity of the gastric outline is shown more definitely, and this method is almost universal.

The screen examination is made with the patient standing and, if necessary, in the recumbent position also. Plates may be made with the patient in either position, but in cases of hour-glass stomach the vertical is preferable.

Hour-glass deformity is so striking in the roentgen shadow of the barium-filled stomach that, save in exceptional instances, it can readily be recognized even by the novice. But, as Groedel[10] well says, the diagnostic task has only begun with the establishment of the presence of an hour-glass form, for the roentgenologist should endeavor to distinguish between the following varieties: (1) Organic; (2) spasmodic, from an intrinsic lesion; (3) spasmodic, from lesions or conditions outside the stomach; and (4) pseudo-hour-glass.

In conformity with its pathologic anatomy the organic hour-glass resulting from gastric ulcer usually shows a B-form. In the roentgen image, the constriction is at the expense of the greater curvature, which is drawn toward the lesser. Almost invariably the cleft is deep and relatively narrow, so that the loculi communicate by a short canal of small caliber. Indeed, the canal may be so stenotic that a portion of the six-hour meal may be retained in the upper loculus, but this is exceptional. However, with a very narrow channel the stenosis may be evident by retarded passage of the barium meal during the screen examination, even if there is no retention from the six-hour meal, and in many cases it trickles very slowly through the aperture, running in a curvilinear course along the lesser curvature.

With these conditions present, the observer can feel considerable certainty that the hour-glass is really organic. Cerne and Delaforge[11] have called attention to another item of some diagnostic significance; the sagging of the upper loculus (Fig. 276). They describe the lower border as curved and encroaching on the cleft, or else completely overhanging it, so that palpatory pressure may be necessary to demonstrate the constriction between the loculi. Often a niche, or accessory pocket,

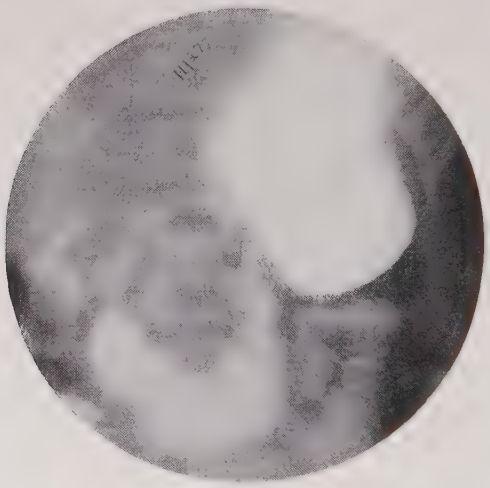

FIG. 276.—(111,279). Organic hour-glass stomach.

is seen on the lesser curvature side of the isthmus associated with hour-glass, and this favors the probability that the hour-glass is organic, although it is not conclusive proof. Fixation of the stomach, as evidenced by its resistance to efforts at displacement by palpation, also suggests that the deformity is organic. An important feature is the fact that neither the position nor the contour of the constriction can be altered by manipulatory massage.

Carcinomatous organic hour-glass is easily recognized, as a rule. The isthmus may be centrally placed, often with a funnel-like expansionat either end, so that it has the form of a script x Fig 277). The contour of the canal is usually irregular, due

to small projections from the tumor mass, and the dim shadows of the growth itself may be visible. If, in addition, a tumor corresponding to the filling-defect can be felt, the evidence is reasonably complete. However, all the cases do not possess these typical characteristics; the growth may involve only one curvature, and in such instances the channel between the loculi lies along the opposite curvature. In many of the cases the condition is, strictly speaking, an hour-glass form of the gastric

Fig. 277.—(172,006). Concentric (*x*) type of hour-glass stomach in a case of gastric cancer.

lumen rather than of the stomach as a whole; the local narrowing of the cavity is caused by the projection of the tumor into the lumen, and judging by the external contour of the stomach as seen at operation, the surgeon would hardly consider it a true hour-glass. Medullary cancer especially may produce an hour-glass deformity of this type.

The scirrhous type, infiltrating the gastric wall, is more likely to result in actual contraction. It is interesting to note

that the carcinomatous hour-glass seldom causes a six-hour retention in the upper loculus, even though the isthmus is quite narrow.

Syphilitic hour-glass stomach may result either from luetic ulceration or hyperplasia. The hyperplastic or gummatous type with filling-defects and a corresponding palpable

Fig. 278.—(218,041). High hour-glass stomach with dilatation of the esophagus in a case of gastric lues. Wassermann positive.

In spite of sounding (25F) and antiluetic treatment the constriction became more marked. The patient lost weight rapidly, from 113 to 79 pounds. Fluids were taken with great difficulty and operation was thought advisable.

Findings at operation: Stomach about 10 centimeters long and from 6 to 7 centimeters in diameter. For a distance of 4 centimeters extending from the pylorus up to the constriction the stomach was contracted to about 1 centimeter in diameter.

Operation: Sleeve resection, with removal of two-thirds of the stomach. Jejunostomy.

mass is not roentgenologically distinguishable from cancer. Syphilitic ulcers are often multiple, and their strong tendency to the production of hour-glass has been frequently noted (Fig. 278). Dewis[12] believes that he has noted a characteristic point which differentiates the condition from cancer and simple ulcer: "In syphilitic hour-glass of the stomach we see a long, regular isthmus, at each end of which the walls of the stomach rise more or less abruptly or dumb-bell-like. This is in contrast to the sharp incision of simple ulcer hour-glass with practically

no isthmus, and the picture differs quite as much from the cancer hour-glass with the infiltrated walls of the stomach sloping irregularly away from the constricted portion." This dumb-bell appearance has also been described by LeWald.[13] I have occasionally observed the appearance which Dewis, and LeWald describe and sometimes fancied that the shadow of the barium-filled luetic stomach showed a peculiar "flatness" as compared with the roentgenograms of other lesions. As a matter of fact, however, the roentgenologist's first suspicion that the lesion is syphilis rather than cancer is usually aroused not by the roentgen picture so much as by certain obvious clinical facts (see Chapter XI).

All forms of organic hour-glass stomach have certain features in common: They are persistent at successive examinations, are not relaxed by a general narcosis and are constant in situation. They cannot be effaced by epigastric massage, and remain unaltered after the patient has been given atropin or belladonna to physiologic effect.

Purely spastic forms of hour-glass, produced directly by gastric lesions and hence conveniently designated as "intrinsic," are seen in association with ulcer and cancer. As stated before, the spastic hour-glass of ulcer, like the organic form, is seen opposite the ulcer in the shape of an indentation of the curvature, usually the greater (Fig. 279). The depth of the indentation varies, but is nearly always greater than its width. Occasionally, when the indrawing is not very pronounced, it may appear as a triangular notch. Each of two or more ulcers may produce an incisure either separately or, if the ulcers are closely adjacent, fused irregularly together so that the margins are not clean-cut. As a rule, the single, deep, spastic incisure is regular in outline, with straight, parallel sides, and this appearance is of some value in distinguishing it from an organic constriction. However, such characteristics have also been observed in organic hour-glass stomach (Fig. 280). In other respects it does not differ from the organic variety, is constant in situation, present at a second examination, cannot be obliterated by palpatory

maneuvers and is still present after the administration of antispasmodics.

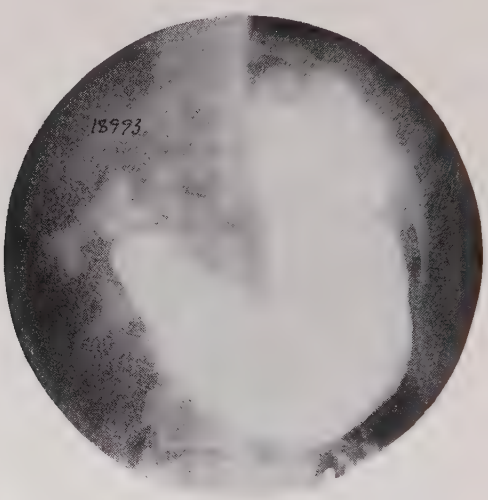

FIG. 279.—(18,933). Intrinsic spasmodic hour-glass stomach.

FIG. 280.—(143,766). Perforated gastric ulcer producing organic hour-glass stomach.

Spastic contraction is associated with gastric cancer less frequently than with gastric ulcer. Usually it is seen as an indrawing of the greater curvature opposite the growth and is

considerably wider than the contraction produced by an ulcer (Fig. 281). The luminal margin of the contraction is often irregular. Rarely a small cancer may provoke a narrow spastic contraction, resembling that of ulcer. The broad spasmodic contraction may be mistaken for a filling-defect produced by the growth itself, but close inspection of the plate will show that the indentation is clearly outlined without any faint shadow of a

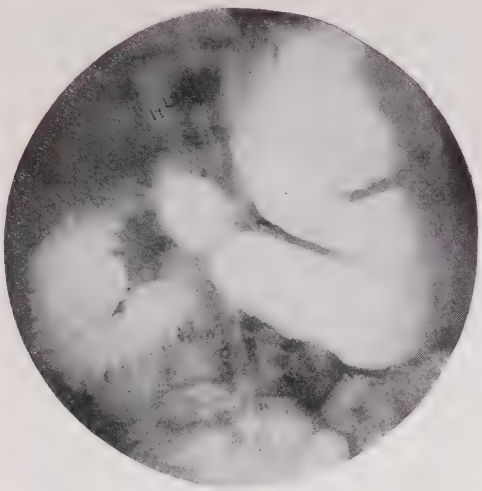

FIG. 281.—(142,921). Intrinsic spasmodic hour-glass stomach in a case of colloid carcinoma on posterior stomach wall. The deformity was not affected by belladonna, and it was not found present at the time of operation.

tumor-mass between the borders, although a shaded filling-defect corresponding to a palpable mass may be seen directly opposite the contraction. The whole picture is, as a rule, so plainly indicative of cancer that the examiner will have little interest in whether the hour-glass is organic or spasmodic, or both. That spasm probably accentuates the various forms of organic hour-glass deformity is supported by the fact that the isthmus depicted by the roentgen-ray is often much narrower than when exposed to view at operation.

Spasmodic hour-glass contraction resulting from, or at all events, associated with, conditions outside the stomach is one of the most deceptive manifestations with which the roent-

genologist has to deal (Fig. 282). Although a definite etiologic relationship is difficult to establish, there are three conditions which are especially prone to be accompanied by some form of gastrospasm, namely, chronic cholecystitis, chronic appendicitis and duodenal ulcer. Gastrospasm is not infrequently seen in morphinism, plumbism, general nervous

FIG. 282.—(20,594). Extrinsic spasmodic hour-glass stomach which relaxed after belladonna to physiologic effect. Note Fig. 284.

states or in timid patients who are frightened by the process of examination. With some of these spastic phenomena, such for example as "total gastrospasm" in which the entire stomach is irregularly contracted, we are not here concerned. Local or regional extrinsic spasms producing hour-glass deformity are most frequently seen as a cleft of the greater curvature, resembling the incisura of a gastric ulcer. With one exception, spastic hour-glass from extrinsic causes can usually be differentiated from other forms of hour-glass. Extrinsic spasm may alter in intensity and thus change in appearance during the examina-

tion; it is relaxed by a general narcosis; it can sometimes be obliterated by steady, forceful, though not violent epigastric massage; it is often absent at a second examination; it disappears after the administration of belladonna to physiologic effect.

The one exception to these eliminative tests is gastric spasm arising from duodenal ulcer. The spasm ranges from a moder-

Fig. 283.—(100,277). Spasmodic hour-glass stomach in a case of duodenal ulcer. The hour-glass was not present at operation because it was relaxed by the anesthesia Such spasms are not relaxed by antispasmodics in our experience.

ate incisure to a pronounced contraction and tends to persist even after full doses of belladonna have been given, so that the observer is inclined to accredit it to a gastric lesion (Fig. 283). The puzzle is further complicated by the fact that a duodenal ulcer and a gastric ulcer may occur in the same case. In every instance of suspected spastic hour-glass, it behooves the examiner to confirm or exclude the presence of duodenal ulcer. If an ulcer is present, as shown by constant distortion of the

duodenal bulb, the presumption is strong that it is the cause of the gastrospasm, although careful search should be made for the niche of a gastric ulcer. If no duodenal ulcer is found and the gastrospasm withstands all eliminative tests, the spastic condition is probably of intrinsic origin, and indicates a lesion within the stomach, even though it cannot be seen (Fig. 284).

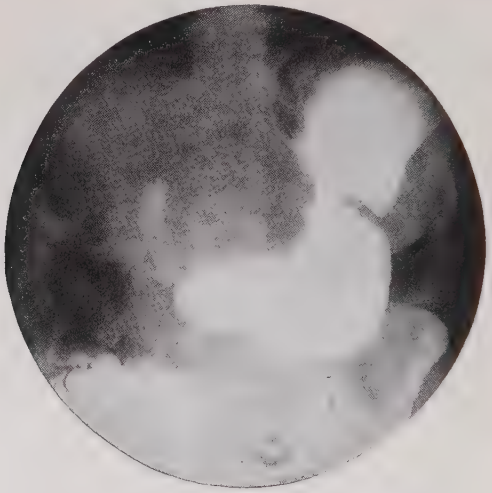

FIG. 284.—(191,809). Intrinsic spasmodic hour-glass stomach in a case of multiple ulcers of the lesser curvature.

In administering belladonna to relax gastrospasm it is emphatically necessary that the amount given is sufficient to produce the usual physiologic effects of dryness of the throat, pupillary dilatation, etc. My custom is to prescribe the tincture, beginning with 1.33 c.c. and repeating the dose frequently, until the desired effect is obtained (Fig. 285). Since some patients have an idiosyncrasy for the drug, it is advisable to keep them under close observation and stop its administration, if untoward symptoms develop.

Atropin sulphate, injected hypodermically in single doses of 0.00065 to 0.0013 gm., is preferred by some examiners. It has the advantage of permitting a second examination soon after the first, probably before the stomach is empty. I have not adopted this practice, because it is impossible to determine the

dose necessary to produce a physiologic effect, and patients usually object to repeated hypodermic injections. On the other hand, belladonna may be given by mouth without any objection from the patient and, so far as my experience goes, the results are all that could be desired.

Conflicting opinions as to the effectiveness of belladonna in abating gastrospasm are probably due to the various forms,

Fig. 285.—(20,594). Same case as Fig. 281. Stomach normal in outline after giving belladonna to the physiologic effect.

methods, and doses in which it is given. Thus, Reizenstein and Frei state: "We must reject the accepted teaching that atropin will differentiate the spastic from the organic forms. We could never convince ourselves of a positive effect of atropin in the sense of relaxing spasm but, on the contrary, have observed an increase of it by this means." Barclay[14] says that belladonna relaxes some spasmodic hour-glass stomachs, while it may have no effect on others that are susceptible to the effects of massage and thus prove themselves to be spasmodic. He

also cites a case in which the stomach was relaxed by belladonna, and yet a healed ulcer was found at operation. Rieder[15] who uses the extract of belladonna, states that only a positive result is of value. Strauss[16] has found both atropin and papaverin very unreliable in his experience. Notwithstanding the testimony of these observers, my own cases of extrinsic hour-glass stomach (barring those produced by duodenal ulcer) which failed to relax after belladonna were only those in which an insufficient amount of the drug had been given, and my confidence in this test remains unshaken.

FIG. 286.—(112,360). Extrinsic hour-glass stomach in a case of gall-bladder disease which relaxed after belladonna to physiologic effect. Note Fig. 287.

It is true that belladonna or atropin will not differentiate intrinsic spasmodic and organic forms of hour-glass stomach, but they will differentiate the intrinsic and extrinsic forms (Figs. 286 and 287). When the hour-glass contraction is the only roentgen sign present, this test must be very carefully carried out, as otherwise the roentgenologist may lead the sur-

geon into error. It has been my experience that any hour-glass constriction that resists belladonna to the physiologic effect means a lesion either of the stomach or duodenum; and regardless of whether the hour-glass is present or not at operation, the surgeon will find the cause, if he looks for it.

Barclay's case of healed ulcer with relaxation of the hour-glass after belladonna is extremely interesting. I have never

FIG. 287.—(112,360). Same case as Fig. 286. Stomach normal in outline after giving belladonna.

observed such a case. Neither have I found massage to have any effect on intrinsic gastrospasm. At the same time, the obvious fact should never be overlooked that in all spasmodic forms of hour-glass stomach the constriction is relaxed by the anesthetic.

Rieder has described a type of hour-glass stomach which he called "cascade stomach." This is simply an hour-glass contracture in which one portion of the stomach is not directly over the other, but they are shifted laterally. The upper sac

is displaced slightly to the left and the lower sac to the right. In some cases this order may be reversed or the displacement may be in the antero-posterior direction so that a lateral view is necessary in order to visualize it. The upper pouch forms a bowl-like cavity overflowing cascade-like into the vertically hanging lower pouch. In all the cases I have seen the etiologic factors have been spasm, gas-distention of the colon, large extrinsic tumors or ascites. Wilucki[17] describes a case due to an extraventricular tumor.

Zehbe[18] reports four cases he had seen in the last year, in all of which the sacs were displaced antero-posteriorly and lateral illumination was necessary to demonstrate them. In three cases the cascade deformity was thought to be due to adhesions, with one operative confirmation. In the fourth case no cause was given.

Stierlin[19] described a case of cascade-form of hour-glass stomach with the pouches displaced laterally, and quoted Rieder, Faulhaber and Groedel as reporting cases.

The name "cascade stomach," while very descriptive of the condition, may seem rather formidable and be a source of undue anxiety to the inexperienced operator. It is, however, not a permanent deformity, but should be classed as a simple hour-glass constriction due to extrinsic causes.

Aside from the hour-glass deformities of the stomach due to actual contraction of the gastric walls, whether organic or spastic, there are pseudo-hour-glass forms, that have certain semblances of the hour-glass as seen with the x-ray, and which may be more or less deceptive to the untrained observer.

One of these is the elongated hypotonic, or so-called atonic stomach. Hurst[20] dignifies it by the term "orthostatic" hour-glass stomach. By reason of its tonusless walls, the stomach is lengthened and its capacity increased. Ingesta which would fill a stomach of average size accumulate in the expanded basin-like lower pole and, with the patient standing, the dragging weight of the gastric contents causes a spindle-like approximation of the walls in the middle third. The ingesta can be forced

upward by manual pressure, so as to dilate the apparent narrowing and thus prove its deception.

Somewhat similar in appearance, and perhaps related to the above, is the so-called corset-stomach, seen in enteroptotic women who are given to tight lacing. However, Groedel believes that the corset-stomach belongs to the scar hour-glass type

FIG. 288.—(147,151). Pseudo-hour-glass stomach due to pressure of stomach against the spine.

and says: "It is anatomically confirmed that foolish tight lacing may give rise to a thickening of the serosa which shows the characteristics of a scar hour-glass." Rieder also lists it as a possibility among the acquired forms but considers it doubtful and very improbable that tight lacing would cause a permanent hour-glass.

A third simulant of hour-glass is that produced by the imprint of a tumor outside the stomach. The indented portion of the gastric wall is usually a wide, smooth incurvation which changes in appearance when the stomach is manipulated.

Other causes of pseudo-hour-glass stomach are, for example, strong retraction of the abdominal wall (Fig. 289) and the supine and prone position of the patient (Fig. 288). Most of these simulants may be easily eliminated by a little manual palpation behind the screen, especially while the patient is in the vertical position.

Practically, then, unless the case is extraordinarily typical, it is only by a process of elimination that the several varieties

FIG. 289.—(111,020). Pseudo-hour-glass stomach due to strong retraction of the muscles of the abdominal wall.

of hour-glass stomach can be differentiated. First, the mere pseudo-hour-glass must be excluded, and this is seldom difficult; next, extrinsic spasm from most causes can be eliminated by the various procedures mentioned, particularly the belladonna test. If the hour-glass persists after this test, the examiner may reasonably assume that the deformity is: (1) organic of itself, (2) intrinsic spasm arising directly from a gastric lesion, or (3) an extrinsic spasm due to duodenal ulcer.

A careful screen and plate examination of the duodenal bulb will either confirm or exclude the presence of an ulcer. If no duodenal ulcer is present, the presumption is strong that the constriction of the stomach is due to a gastric lesion, with the

Fig. 290.

Fig. 291.

Fig. 292.

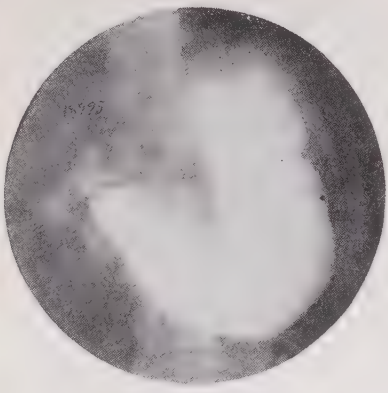

Fig. 293.

Fig. 294.

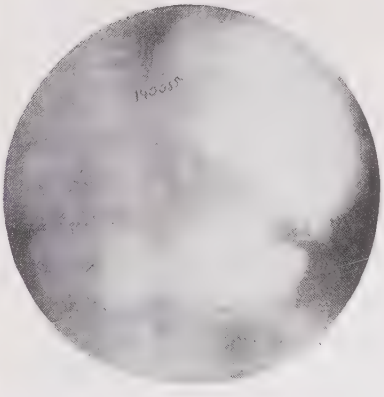

Fig. 295.

Figs. 290, 291, 292, 293, 294 and 295.—Examples of spasmodic hour-glass stomach.

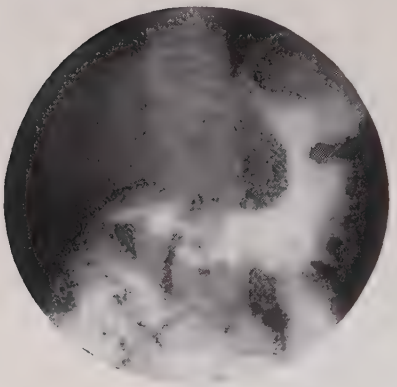

FIG. 296.

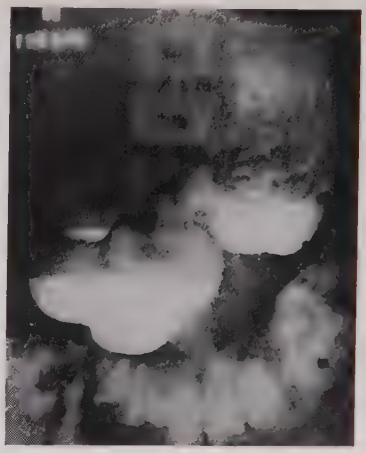

FIG. 297.

FIG. 298.

FIG. 299.

FIG. 300.

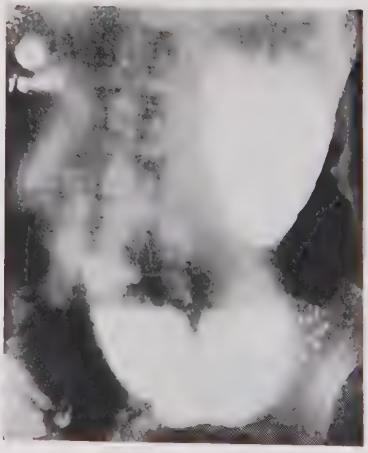

FIG. 301.

FIGS. 296, 297, 298, 299, 300 and 301.—Examples of organic hour-glass stomach.

chances favoring ulcer or its scar, even though the niche of the ulcer cannot be seen. If a duodenal ulcer is found, it may be inferred that the hour-glass is a spastic reflex from the ulcer, although this inference is not absolutely safe, since about 11.5 per cent. of duodenal ulcers occur in association with gastric ulcer. When the field has been logically narrowed to a choice between an hour-glass deformity which is organic of itself and one which is spastic but arising from a gastric lesion, the examiner is likely to concern himself more with the nature of the cause than the manner in which the hour-glass effect is produced. In other words, he is more interested, and properly so, in deciding between ulcer, cancer, and syphilis, than in determining whether the hour-glass is due to intrinsic spasm or to permanent contraction. If the upper loculus shows a retention from the six-hour meal, or if the upper loculus sags to the left and below the cleft, or if there are irregular filling-defects about the isthmus typical of cancer, the examiner may be quite confident that the constriction is at least partly organic and will be found by the surgeon. But if with a tight hour-glass constriction there is neither a retention from the six-hour meal, nor a retarded flow of the barium suspension, if no niche, accessory pocket, or filling-defect is visible, and the indentation has straight, parallel borders, the contraction is probably spastic and will not be seen by the surgeon at operation.

CONCLUSIONS

1. Hour-glass stomach should not be considered a disease entity, but an end-result of various pathologic processes, gastric and perigastric.

2. The possibility of congenital hour-glass stomach must be admitted, although most cases reported have been questioned.

3. The roentgenogram usually shows a much deeper constriction than is seen at operation, owing to the fact that the organic narrowing is exaggerated by the spasm.

4. Cases of spasmodic hour-glass, whether intrinsic or extrinsic in cause, are not seen by the surgeon, because they are

relaxed by the narcosis. Therefore, if the hour-glass is the only roentgen sign present, the first thing to do is to exclude extrinsic causes.

5. Belladonna or atropin does not effect a differentiation between the organic and intrinsic types of spasmodic hour-glass stomach.

6. Belladonna or atropin to physiologic effect will differentiate between the intrinsic and extrinsic types of spasmodic hour-glass stomach.

7. Operations have proved the organic type to be the most common. However, the spasmodic type, when intrinsic in origin, is just as important from a diagnostic standpoint, as the organic.

8. Spasmodic hour-glass of extrinsic cause is not common.

9. The varieties of hour-glass stomach, therefore, admit of the following subdivisions:

A. Congenital.

B. Acquired.

1. Organic; constriction due to structural changes in or about the stomach. Causes: ulcer, scar of healed ulcer, perigastric adhesions, cancer, syphilis, corrosives, resection, gastrostomy.
2. Spasmodic (or functional); cramp of the gastric muscle without structural change. Two types: (*a*) Intrinsic; cramp directly produced by lesions in the stomach; causes practically the same as those of organic hour-glass; (*b*) extrinsic; cramp indirectly produced by causes outside the stomach; duodenal ulcer, diseases of the gall-bladder, disease of the appendix, neuroses, tabes, lead intoxication, morphin, nicotin.

C. Pseudo-hour-glass. This simulates the hour-glass form without either spasm or structural change in the stomach, and is caused by contraction of the abdominal muscles, pressure of the stomach against the spine, tumors outside the stomach, atonic stomach or gas and fecal matter in the bowel.

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CHAPTER XV

MISCELLANEOUS GASTRIC CONDITIONS

Hair-ball and Other Foreign Bodies—Diverticula—Diaphragmatic Hernia and Elevation of the Diaphragm—Gastroptosis

HAIR-BALL

Unique among the foreign bodies which are occasionally found in the stomach, the hair-ball (trichobezoar) possesses almost theatrical interest.

Butterworth[1] was able to collect 42 cases from the literature including one of his own. He gives an extensive bibliography. Moore[2] has found 11 additional published reports, to which he gives references, and adds one himself.

Burchard[3] reviews some of the cases that were examined by the roentgen-ray, including Franke's[4] and Schwarz's.[5] In Franke's case there was a hard, smooth, painless tumor in the region of the stomach. In the roentgen picture there was an irregularly mottled shadow ending in an arch above. The diagnosis of trichobezoar was made on the combination of the clinical and roentgen findings and was confirmed at operation. Schwarz's case showed no complete bismuth shadow of the stomach, but only a streak along the greater curvature.

In Kampmann's[6] case also, that of a ten-year-old girl, the mass filled the stomach. The roentgen-ray showed uneven distribution of the bismuth meal. No gas-bubble was present. Clairmont and Haudek[7] describe a case in which a hair-ball of moderate size could be displaced into the upper portion of the stomach and its arched shadow could be seen in the gas-bubble.

Hüttenbach[8] gives extensive details of the case of an eighteen-year-old woman. At the roentgen examination of the stomach the contrast meal showed an uneven splotching. The gas-

FIG. 302.—Holland's case of hair-balls in the stomach.

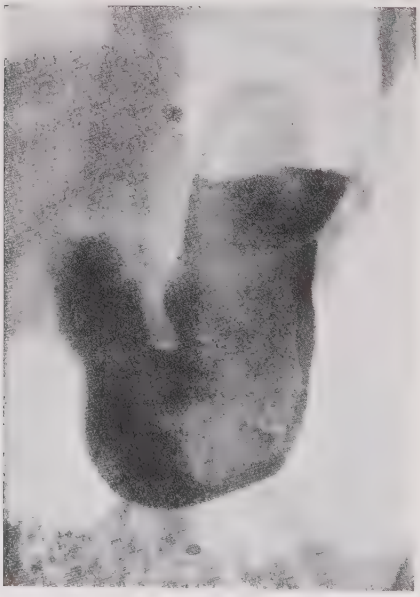

FIG. 303.—Hair-ball in the stomach (Ramsbottom and Barclay). The projection of the hair-mass into the gas-bubble is well shown.

bubble could not be seen. At operation the hair-ball was found to form a complete cast of the gastric cavity, with a small projection into the duodenum. It was quite hard, though porous, and covered with a grayish-white bacterial growth.

Holland's[9] patient was a young woman, aged 29. The upper abdomen was occupied by a very large tumor which reached to the umbilicus. When examined with the screen, the barium sulphate mixture rapidly mapped out the stomach though somewhat faintly, but showed two dark transverse bands. Later, a definite history of hair-swallowing was obtained. At operation three large hair-balls were removed. They filled the stomach almost completely. The peculiar roentgen appearance was evidently due to the barium mixture flowing between the wall of the stomach and the hair-balls, and to a certain extent sticking to the surfaces of the latter, while the dark bands were caused by the opaque meal entering the joints between (Fig. 302). The case reported by Ramsbottom and Barclay[10] was that of a woman aged 28, who gave a history of gastric disturbance for a few weeks only. In the left abdomen was a large, but not tender, freely movable tumor, which was at first believed to be the spleen. When examined roentgenoscopically by Barclay the bismuth meal surrounded the mass and outlined the curvatures of the stomach. By palpation the tumor could be shifted upward, the top of it rising above the bismuth and showing a rounded shadow in the gas-bubble (Fig. 303). Barclay gave the opinion that the mass was a hair-ball. Subsequently it was learned that twenty years previously in an attack of scarlet fever the patient had eaten practically all of her hair. At operation the hair-ball was found to be 22 cm. long by 8 cm. wide, with a process extending into the duodenum.

For obvious reasons, by far the greater number of hair-balls are found in females, and more often under the age of 20. Three or 4 cases, however, have been reported in boys and men. Neuroses, dementia, mania, and idiocy play a part. The form and size of the hair-masses vary. Large bezoars usually form casts of the gastric lumen; the smaller ones may be spheric or kidney-

shaped. In one case reported, the mass weighed more than 4 pounds.

The symptoms of the condition are not distinctive. They include loss of appetite, pressure, distress, pain and vomiting. The patients usually complain most after eating (Hüttenbach). In some instances small hair-masses have been discovered in the

Fig. 304.—Case 148,917. Photograph of hair-ball after removal from stomach, showing a mass of hair, hay, and rags.

stools, and in one case they were ejected by vomiting. The palpable tumor is freely movable, and has been variously mistaken for a splenic, pancreatic or renal growth, or a fecal accumulation in the colon.

In most of the cases that were subjected to roentgen examination it is noteworthy that the opaque meal penetrated between

the wall of the stomach and the hair-mass, thus visualizing a regular gastric contour, but the area occupied by the hair-ball was only faintly and diffusely shadowed. When, in addition, the tumor-mass can be displaced upward into the gas-bubble, the evidence of a foreign body is complete. A combination of the roentgenologic and clinical findings should always establish the diagnosis. During the past two years 2 cases have been seen in the Mayo Clinic. Unfortunately, neither of the patients was examined by the roentgen-ray.

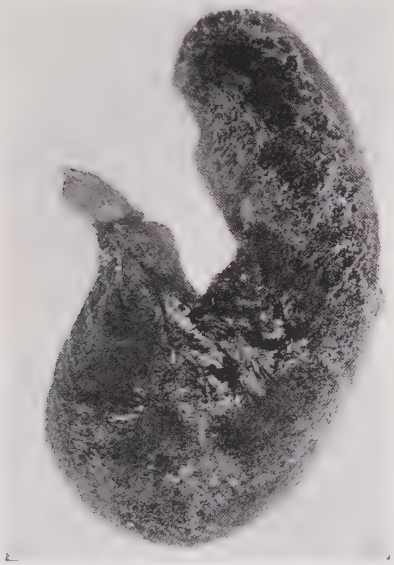

FIG. 305.—Case 107,244. Photograph of hair-ball.

Case 148,917, female, aged 32 years. The patient has been an inmate of the State Hospital for Insane during the past eighteen months, and on previous occasions for a year at a time in other hospitals. She complains of attacks of abdominal pain, coming at intervals of one to six months, and lasting two weeks. The pain is rather diffuse but worse on the left side and is associated with nausea and vomiting. Hemoglobin 75. Movable mass, like a floating spleen, in left epigastrium. Findings at operation: Hair-ball 25 cm. long in stomach, was removed through anterior longitudinal incision. Pathological report: Foreign body. Mass composed of hair, hay, strings and cloth. Weight 240 gm. (Fig. 304).

Case 107,244, female, aged 10 years. Scarlet fever at 9 years of age. Well until ten days ago, when she had a "bilious attack," with headache, cramping abdominal pain, and nausea; slight fever. She is restless at night and pulls and chews her hair. Hemoglobin 75. Large, hard, irregular, freely movable, mass, extending obliquely from left costal margin to right abdomen. The mass is not tender and crepitates on palpation. Findings at operation: Large hair-ball, almost filling stomach. Gastrotomy and removal of mass. Pathologist's report: Hair-ball. Weight 2 pounds (Fig. 305).

OTHER FOREIGN BODIES

The foreign bodies which are swallowed either accidentally or intentionally are most often metallic, and their detection in the stomach by the roentgen-ray is not usually difficult. Occasionally, when it is uncertain whether the object is within the stomach or has passed into the bowel, the opaque meal or enema may be of assistance. If the shadow of the foreign material is enveloped in that of the meal in the stomach at all angles of view, its intragastric location may be assumed. The meal may also aid in finding non-opaque bodies.

Case 141,504, female, aged 29 years. Patient at the Rochester State Hospital for Insane, in good physical health and apparently suffering no distress. By chance, the nurse in charge saw a teaspoon disappear into the woman's mouth and she was brought to the clinic. Roentgen findings: Spoons in stomach nested together. Hairpin (Fig. 306). At operation seven teaspoons lying together "spoon fashion" were found, together with a hairpin, some straw and small pieces of twigs. No injury to the gastric mucosa was discovered. The spoons, which were of plated metal, were not eroded. They were each 15 cm. in length and 4 cm. across the bowl. Recovery was uneventful.

Case 151,406, infant, ten months old. The youngster pulled off its stocking, removed an open safety-pin and swallowed it. The roentgenogram herewith shows the open safety-pin in the stomach (Fig. 307). The case is remarkable from the fact that the pin, though open, passed through without hindrance.

DIVERTICULA

Few cases of gastric diverticula have been found in man. The excavation into adjacent tissues sometimes produced by

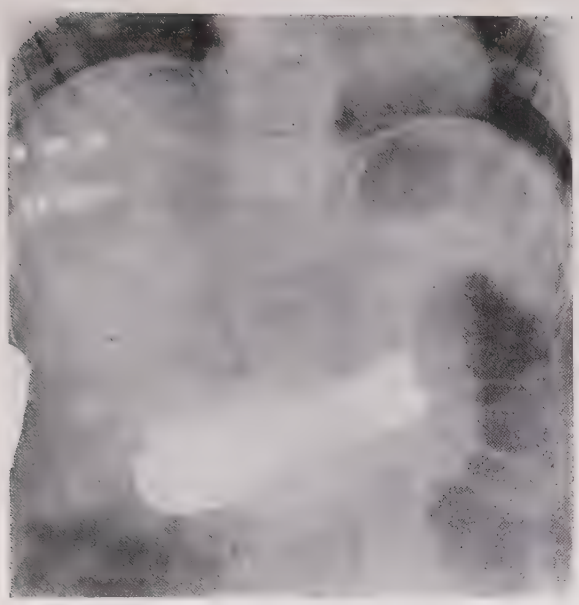

FIG. 306.—Case 141,504. Nested spoons and a hairpin in stomach.

FIG. 307.—Case 151,406. Open safety pin in infant's stomach.

perforating gastric ulcer is not really a diverticulum, though often thus named. Even the designation "false diverticulum" is hardly applicable, and I have therefore selected the term "accessory pocket" (see "Gastric Ulcer"). Pathologists customarily divide diverticula into the "true" and "false." In the former the diverticular sac contains all the coats of the viscus-mucosa, muscle and serosa; in the false type one or more

FIG. 308.—Case 90,125. Diverticular sac at *d*.

layers are missing, most often the muscular, in which case the condition has been described as "hernia mucosæ."

Falconer[11] reports a congenital diverticulum of the stomach, found at necropsy. It arose from the pyloric canal on the greater curvature side, 2 cm. in length and admitted the forefinger. In C. H. Mayo's[12] case the diverticulum was on the anterior wall of the stomach, 5 cm. from the pylorus. It was 4 cm. in length and contained a well-marked carcinoma in its outer portion.

One case of gastric diverticulum has come under my observation:

FIG. 309.—Case 90,125. Photograph of specimen. Diverticulum at *d*; ulcer at *u*.

FIG. 310.—Case 90,125. Outside view of diverticular sac, *d*.

Case 90,125, male, aged 54 years. Twenty-year history of stomach trouble. Attacks usually in autumn, lasting some weeks, of epigastric pain, two hours after meals, relieved by vomiting. Present attack has lasted three months, the pain is of a burning character, comes two or three hours after meals, and is relieved by vomiting. Weight loss, 25 pounds. Total acidity 36, all free; food remnants. Hemoglobin 60. Roentgen findings: Small retention from the six-hour meal in what was believed to be the duodenal bulb. Hyperperistalsis. Bulb irregular. Diagnosis: Duodenal ulcer (Fig. 308). Findings at operation: Obstruction at the pylorus believed to be due to a duodenal ulcer. Operation: Gastro-enterostomy. Findings at autopsy: The specimen taken from the stomach, post mortem, is illustrated in Figs. 309 and 310. In Fig. 309 two depressions are seen just proximal to the pyloric ring. One of these is a callous ulcer, the other, near by, is the opening of a diverticulum.

DIAPHRAGMATIC HERNIA AND ELEVATION OF THE DIAPHRAGM (EVENTRATION)

Diaphragmatic hernia, with protrusion of the stomach or other abdominal viscera into the thoracic cavity, and a related condition, elevation of the diaphragm, though not common, are of some practical importance. Both may give rise to marked gastric symptoms. The former is an actual rupture of the diaphragm. The latter is not, although the term "eventration," which is frequently used as a synonym, implies a rupture. While either may affect the right half of the diaphragm, nearly all the cases reported have been left-sided. Elevation is usually, if not always, congenital, or due to inborn weaknesses. It is not surgical. Diaphragmatic hernia may be either congenital or acquired. It is generally surgical. In the traumatic form, the history of a crushing injury of the lower thorax and upper abdomen, or a sudden doubling of the body with the knees against the chest, can often be obtained.

The clinical symptoms and physical signs of the two conditions are not essentially different, and the roentgen examination affords the most effective means of exact diagnosis and of differentiating the one from the other. Among those who have written concerning the roentgen signs may be mentioned Giffin,[13]

Becker,[14] Sailer and Rhein,[15] Arnsperger,[16] Kienböck,[17] Hildebrand and Hess,[18] and Königer.[19]

Examination with the opaque meal is preferable, although much can be determined without it, or by inflating the stomach. With the patient recumbent, either prone or supine, the elevation or herniation is more accentuated than in the standing position.

In left-sided elevation of the diaphragm (eventration) the left arch of the diaphragm, which is normally lower than the

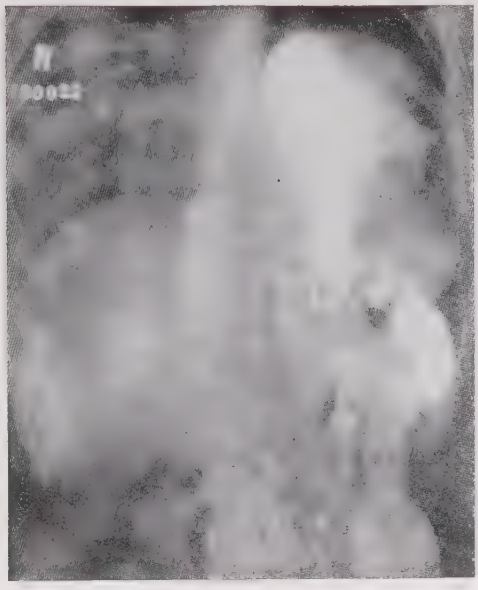

Fig. 311.—Case 136,932. Barium-filled stomach high in left chest.

right, is now seen to be markedly higher than its fellow, and its convexity is increased. The heart is either raised or displaced to the right. The gas-bubble (patient standing) is forced upward with the arch, is increased in size, and no shadows of lung-tissue are seen within the transparent area of the bubble. Both arches show respiratory movement, though the excursions may be shorter. On filling the stomach with the barium meal, its high-lying position becomes evident.

FIG. 312.—Case 136,932. Colon-ray on two plates. The splenic loop extends up to the second left intercostal space.

In left-sided diaphragmatic hernia the roentgen signs are usually more marked. The heart is displaced to the right by the herniated stomach. Through the gas-bubble, which is usually increased in size, lung-markings may be seen. The dome-shape of the left arch is lost, if the arch can be made out at all. Especially notable is the "paradoxic respiratory phenomenon"; on forced inspiration the right diaphragm descends while the clear area in the left chest rises; in expiration the

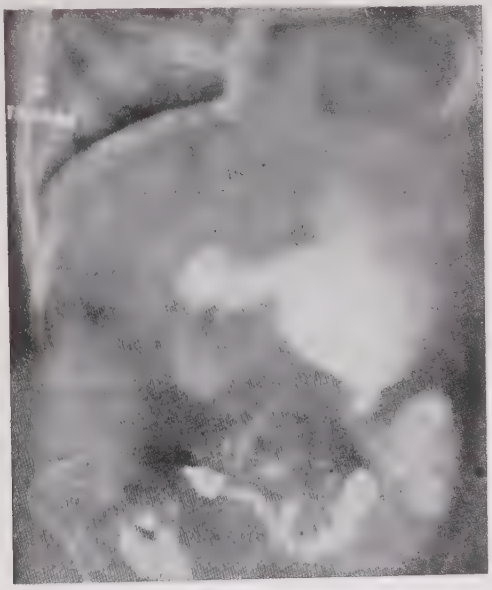

FIG. 313.—Case 136,932. Stomach after operation.

reverse occurs. This point differentiates hernia from elevation. By giving a barium meal the herniation of the stomach may be established. In some instances the colon also takes part in the hernia, and this may be shown by examination with an opaque enema.

Case 136,932, male, aged 47 years, conductor. Four years ago in a railway accident his chest was crushed by logs falling from a car. Following this he began to have severe gastric distress about two hours after meals. At times the pain is extreme. It is made worse by food. Relief is secured by abstinence from food or a quick physic. Meats,

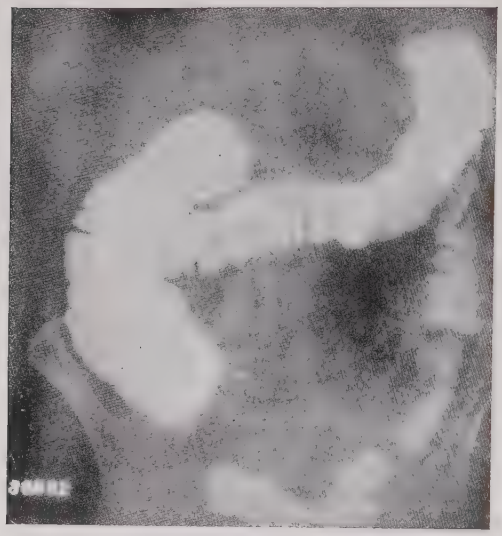

FIG. 314.—Case 136,932. Colon after operation.

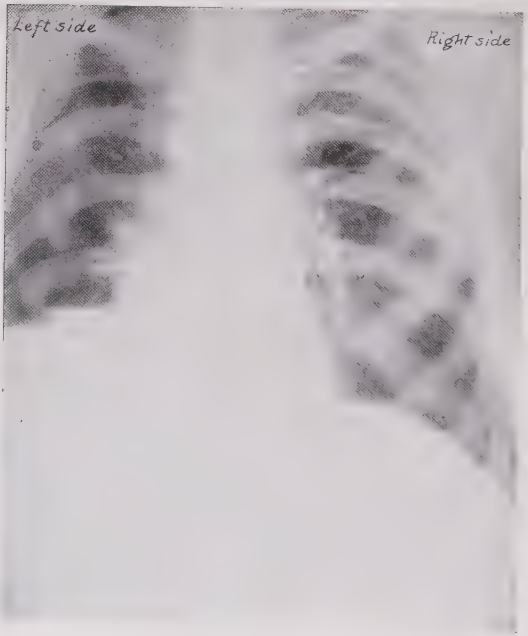

FIG 315.—Case 136,932. Note the left diaphragm after repair. The broken ribs may also be seen on the left side.

potatoes and fruits are especially distressing. He is sometimes conscious of gurgling and rumbling in the left chest. Total acidity 20; free 10; combined 10. Physical examination showed displacement of the heart to the right. Under forced respiration splashing sounds of fluid and air were heard as high as the left nipple. Roentgen findings: No retention from six-hour meal. Stomach high up in left chest, is distorted and partially rotated (Fig. 311). Old fractures of left ribs. Diagnosis: Hernia or eventratio diaphragmatica. Colon ray: Splenic

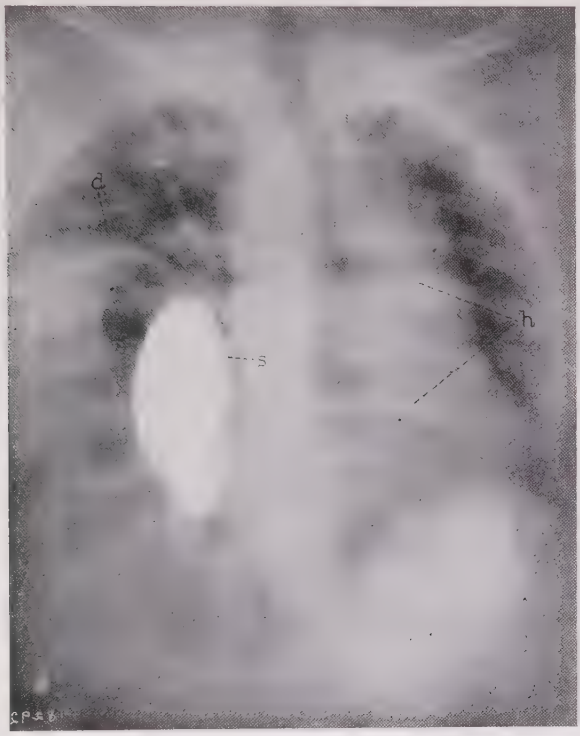

Fig. 316.—Case 28,068. Elevation of left diaphragm (eventration). Barium in stomach, *s*.

flexure in left thoracic cavity. Diagnosis: Hernia diaphragmatica (Fig. 311). Findings at operation: Hernia through left diaphragm. Hernial opening about 15 cm. in circumference. Chest-cavity contained part of small intestine and the greater portion of the colon spleen and stomach. The opening was sutured. The patient also has a gastric ulcer on the lesser curvature about 4 cm. from the pylorus, and an ulcer on the posterior wall of the duodenum which may

require operation later. (Neither of these could be determined at the roentgen examination, because of the malposition and distortion of the stomach.) The condition after operation is shown in Figs. 313, 314 and 315.

Case 28,068 (x-ray No. 18,292), male, aged 58 years. The patient complains of shortness of breath on exertion. He has noticed this for ten years or more. No pains in left chest. He has known for ten years that his heart is on the right side. No marked tympany at left base; slight change in note. Breath sounds distant. Vocal fremitus much diminished at left base. Coin sound not typical but rings with coin just inside left nipple. Tinkling sounds from stomach heard in front. Signs not definite. The roentgenogram (ventrodorsal view), Fig. 316, shows the high-arched diaphragm reaching to the fourth costal interspace. Its unbroken outline can be traced throughout. Beneath the diaphragm is the stomach containing a small quantity of bismuth food. The heart shadow lies entirely to the right. On fluoroscopy both arches of the diaphragm moved in unison during respiration.

GASTROPTOSIS

Notwithstanding a wealth of literature on the subject of gastroptosis there is still widespread disagreement, not only as to its significance and proper treatment, but even as to what constitutes the condition. The work of Glénard, who is generally credited with the first detailed descriptions of ptosis of the thoracic and abdominal viscera, attracted a large retinue of followers, especially during the past two decades. Nephroptosis received the bulk of attention for some years, and its rise and decline in clinical and surgical favor is a familiar story. Later, gastroptosis and enteroptosis came into greater prominence, and have been given recent emphasis by Lane's work on stasis.

Gastroptosis may be defined as a downward displacement of the stomach. But here, as with many other medical terms, the definition is by no means equivalent to a description of the condition, nor does it carry an unvarying meaning. At first thought gastroptosis appears to be a simple term which designates a specific condition, yet the most casual scanning of the

literature reveals a broad divergence of opinions as to what gastroptosis is.

The clinical conception of gastroptosis was based originally on the physical signs obtained after inflation of the stomach, the patient being examined in the recumbent position usually. The stomach was outlined by percussion and the umbilical level was taken as the normal limit of the lower gastric pole. Descent of the greater curvature below this level was regarded as indicative either of gastroptosia, or gastrectasia, or both combined. Then came the roentgenologic method of examination with the opaque meal. Patients were examined in the standing position as a rule, but the umbilical landmark for the greater curvature was retained. Consequently, roentgenologists were annoyed to find that the majority of stomachs fell below the normal standard. Hampered by this fixed idea, the effort to establish a normal roentgenologic stomach which would harmonize with the normal clinical stomach was laborious. Many condemned the roentgenologic stomach as an artefact. It was contended that the weight of the bismuth dragged the stomach far below its natural level and distorted its form. In respect to this contention it should be stated that while the stomach does lie at a lower level when the patient is standing than when he is recumbent, the difference is not due to any extraordinary weight of the opaque meal.

Nevertheless, the general acceptance of gastroptosis as an important entity has obliged many roentgenologists to attempt its diagnosis. As a result they offer conflicting diagnostic criteria. Hurst[20] states that "complete gastroptosis is present when the stomach is not only abnormally low in the erect position, but the greater curvature reaches below the umbilicus in the horizontal position." Kaestle[21] says: "If the greater curvature of a stomach, not dilated, stands below the navel, with a more or less high-lying pylorus above, one speaks of gastroptosis." On the other hand, Groedel[11] "puts pyloroptosis in the first place, recognizing it by the course of the pars horizontalis superior, the low position of the pylorus and its abnormal mo-

bility." Further, he notes fundus-ptosis, resulting in a small gas-bubble. Schlesinger[23] holds that the cardia must take part in the ptotic process. Of greater indicative value than sinking of the pylorus, he thinks, is its turning out of its original horizontal position into a vertical or left oblique direction. He sums up the three factors in gastroptosis as follows: (1) Lengthening of the gastric wall. (2) Drawing down of the cardia and upper pole of the stomach. (3) Sinking and rolling up of the pylorus. Béclère and Mériel[24] point out that the stomach never leaves its attachment to the diaphragm. They prefer, therefore, to speak of the "lengthened stomach" rather than the "ptosed stomach." They distinguish two kinds of lengthened stomach; one with normal tone, tubular in form; the other atonic, with expanded lower pole, inclining to delayed motility.

In the discussion of the normal stomach (Chapter VI) I have endeavored to emphasize the relation of the form and position of the stomach to gastric tone, abdominal tension and—chief of all—the habitus of its possessor. Habitually in enteroptotic persons and quite often in persons of normal build, I have found the lower gastric pole far below the umbilical level. In most instances no definite gastric symptoms existed. When they did exist the stomach was usually found to be anatomically normal at operation, and the symptoms were explained by the discovery of some other lesion within the abdomen. On the whole, I am quite willing to record the opinion, from a roentgenologic standpoint, that the position which the stomach occupies in the abdominal cavity is its least important characteristic.

Most of the work on gastroptosis was done with the idea that there was just one standard type of stomach. Any stomach occupying a lower position than this supposed normal type was considered ptosed. The relationship between certain types of physique with certain types of visceral topography, tonus and motility were entirely overlooked. Indeed, this relationship is so constant that one may predict with confidence the type of stomach in a given case from the person's build. If they do not correspond, the question of an abnormal stomach is raised.

Mills[25] states: "We may no more assume a single standard of visceral topography than we may select one type of physique as normal for all persons." Therefore, we have come to appreciate the fact that no organ or structure in the body is subject to such variations in form, as is the stomach. Its form and position are dependent on the physique of the person and no stomach should be accused of being ptosed without due consideration of these facts. I do not mean to imply that gastroptosis does not exist, but so long as the visceral topography and physique correspond there can be no ptosis. If an apparently innocent stomach of the asthenic person were found in an hypersthenic person I could then conceive of its being ptosed.

The clinical status of gastroptosis is likewise somewhat precarious. Recent writers on diseases of the stomach speak guardedly of ptosis. Bassler[26] says that "the special objective signs that constitute a prolapsed stomach are to some extent still a matter of personal equation with each observer." Stockton[27] states that "gastroptosis is usually unaccompanied by symptoms sufficiently specific to lead one to suspect its presence." Much of the import of gastroptosis rests on the assumption of gastric drainage by gravity, a conception which Cannon regards as unfortunate. The functioning of the pylorus and the gastric tone have far more effect upon gastric motility than the height of the pylorus above the lower pole. The low-lying stomach is usually hypotonic, and for the latter reason is likely to show moderate delay of evacuation, but I have not seen a delay beyond six hours from this cause alone. Lack of familiarity with the numerous surgical lesions in other parts of the digestive tract, even entirely outside of it, which give rise to gastric symptoms, is possibly accountable for many of the diagnostic favors which have been bestowed upon gastroptosis. Zealous use of the roentgen-ray in the search for abnormalities of the stomach is seldom unrewarded, and some degree of "gastroptosis" is the rule rather than the exception.

The roentgen-ray will show the position of the stomach, and the roentgenologist may, indeed he should, report this as a detail

of his findings to the physician in charge. But the examiner should not, as is sometimes done, inform an enteroptotic hypochondriac that his trouble is a "dropped stomach," and thus give the patient additional cause for somber introspection. It is doubtful whether the roentgen examiner is ever justified in a diagnosis of "gastroptosis," in view of the varying weight which attaches to the term. Responsibility for this diagnosis belongs to the patient's medical counselor. Though we are not here directly concerned with the treatment of gastroptosis, whether medical or surgical, the following remarks by Stiller[28] are interesting.

"Surgery, intoxicated by its triumphal invasion into the domain of the internist, has brought out various operative methods in the treatment of gastroptosis, which correspond to the narrow gross anatomical viewpoint. If the atonic stomach is too broad, they cut out a piece of the gastric wall; if it has sunk down, they stitch it up, shorten it by folding it, fasten it to the liver, or fix it to the rib-cartilages, in order to eliminate the respiratory movability which a wise nature has provided. Portions of the weak abdominal wall have actually been excised. From the standpoint of the asthenia this is all raw vandalism. For, wholly apart from the fact that suppressing the symptoms does not mean the cure of the great underlying asthenic trouble, we cannot as yet regard the stomach as simply an anatomical pouch; it has indeed, so to speak, a physiologic importance. If there is impairment of its motor function, which the surgeons wish to improve by their operative arts, it will not be made better by a resection-scar, by stitching up, by folding, or by fixation to the belly-wall, whereby the natural movability of the organ is directly harmed."

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CHAPTER XVI

THE STOMACH OF INFANTS AND CHILDREN

Flesch and Peteri,[1] who examined 72 children by the roentgen method, state that the normal stomach of infants, "filled with physiologic fluid food," has the form of a bagpipe, has a large gas-bubble, is horizontally situated, and shows no peristalsis. When given pap-like food, the air-bubble is smaller, the stomach shows a descending and a horizontal portion, and peristalsis is present. Alwens and Husler[2] find that the form and position of the infant stomach depends on the amount of filling, the position of the body, etc., and peristalsis is manifest with both fluid and pap-like foods. They found the evacuation-time for fluid food to be about three hours, but occasionally they noted small bismuth residues after five hours in healthy sucklings. The normal evacuation time of 200 c.c. of pap is from three to three and a half hours.

Ladd[3] observed a curious lack of peristalsis in the normal infant's stomach as compared with that of adults. The stomach appeared to squeeze out the food by contracting as a whole upon its contents, seldom showing the marked indentations so characteristic of peristaltic waves in the adult. In the normal case, he states, some of the food appears in the small intestine as soon as the plate can be taken after feeding. The emptying process goes on rapidly at first, the major part of the contents being expelled in from one and one-half to two and one-half hours, both in breast-fed and bottle-fed babies. After two hours there is a slowing of the emptying process and four to five and a half hours may elapse before all traces of bismuth disappear. In one case, a normal baby, he noted a considerable residue after seven and one-half hours. The age of the child and its individual peculiarities, the quantity and composition of the food, may all be factors influencing gastric motility. The suggestion is strong,

he observes, that the casein of cow's milk when given in high percentage decidedly prolongs the evacuation-time. If the casein is precipitated before it is given, emptying time is greatly accelerated. The presence of fat has no retarding action, and in some cases seems to favor the exit of the gastric contents.

Sever[4] examined 83 children to find the position of the lower gastric border. The stomachs were nearly all of the fish-hook form, and plates were made with the patient standing. The lower border was at the fourth lumbar vertebra in 25; at the level of the iliac crests in 9; and well below the crests in 49, often 3 or 4 inches below. He thinks, therefore, that a low-lying stomach in a child does not necessarily mean a pathologic ptosis.

Willox[5] concludes that the shape of the stomach with contents in children is not a fixed one, but presents many differences during the process of digestion. As a rule, in infants, the shape is more or less globular, becoming elongated and J-shaped as the child grows older. Willox found the average emptying-time of the stomach to be three and three-quarters hours, and thinks that the composition of the food has less effect than bulk and consistence on gastric motility. In some cases the food begins to pass through the pylorus practically as soon as the meal has been taken, while in others there appears to be a resting stage before peristalsis commences.

Pisek and Le Wald[6] in their investigations used 10 per cent bismuth subcarbonate fed by gavage. They concluded that there is no definite normal type of stomach in the infant. It is horizontal rather than vertical in position as compared with the adult stomach. They noted three forms, the ovoid (bagpipe), the tobacco-pouch (retort-shape) and the pear-shape. The shape of the stomach seems to depend largely on the quantity of gas which it contains or acquires, and the amount of gas is less when semi-solid food is taken. The Rieder hook-form was observed only once, occurring in a six-months-old infant. The lesser curvature often was not clearly outlined. In the majority of cases the pylorus was comparatively high and behind the pyloric third. Food passed out rapidly. A large number of

stomachs practically emptied themselves within an hour. The stomach tends to expel its gas accumulation soon after the entry of food, to diminish in size generally and to shorten its axis by drawing upward and to the left.

CONGENITAL PYLORIC STENOSIS

While the symptom-complex of vomiting, visible peristalsis and palpable pyloric tumor is deemed pathognomonic of infantile pyloric stenosis, the aid of the roentgenologist is sometimes solicited, especially in the spastic and atypical cases. Opinions as to the value of the roentgen examination are contradictory. La Fetra[7] thinks that the roentgen-ray is not at all essential for the diagnosis and is often misleading. Richter[8] says that it cannot be relied on implicitly, as bismuth will pass through the pylorus, though slowly, in some cases of stenosis. Reuben[9] regards the roentgen-ray as of little value. He mentions a case of a child sent to a roentgenologist, who told the mother that an operation would be necessary as no bismuth passed into the duodenum during twenty minutes' observation. Reuben states that the patient was doing perfectly well under medical care.

On the other hand, Dunn and Howell[10] found the method useful in determining the degree of pyloric obstruction, the emptying-time and the size of the stomach. Their experience included 6 cases of pyloric spasm, 6 of complete stenosis and 3 of partial stenosis.

Le Wald,[11] whose observations have been extensive, argues strongly for the roentgen examination. He presents a series of roentgenograms showing different grades of pyloric obstruction. In one instance some of the meal was seen going through the pylorus early; operation was not performed. In another case none of the meal passed out into the duodenum, even up to fifty-two minutes after ingestion, and operation was regarded as imperative (Fig. 317). Dilatation was also marked in the latter case.

From the material published it would appear on the whole, that the roentgen-ray can give substantial aid in the diagnosis of congenital pyloric stenosis, whether spastic or organic. Certainly the degree of pyloric patency, the time required for gastric evacuation and the presence or absence of dilatation can be determined better by this than by any other means. The differentiation of organic from spasmodic stenosis ought to be possible by a reëxamination after giving belladonna or papaverine, though I have found no recorded instance in which these

FIG. 317.—Congenital pyloric stenosis in an infant eight weeks old. No bismuth passing the pylorus up to fifty-two minutes. (From Le Wald, in Johnson's Therapeutics.)

drugs were thus employed in infants. The opinions above quoted, adverse to the value of the roentgen examination, doubtless arose from faulty technic or incautious interpretation of the results. Admitting my absolute lack of personal experience with the roentgen manifestations of infantile pyloric stenosis, I would venture to suggest, nevertheless, that the examiner should be careful in basing a diagnosis upon the early rate of gastric evacuation alone. In adults I have repeatedly seen instances in which no barium was seen to pass the pylorus for a considerable time after its ingestion, yet no organic stenosis existed, and it is not irrational to suppose that this might also occur in infants. It would seem that the examiner should take account not only of the initial pyloric outflow but also of the total time required

for gastric evacuation, the presence or absence of gastric dilatation, and the total clinical picture.

AËROPHAGY IN INFANTS

Leven and Barret[12] agree with other observers that the normal infant stomach contains considerable air. While nursing, the air is usually expelled in proportion as the stomach is filled. But they have seen cases in which the air was not expelled and gave rise to vomiting. Immediately after nursing, the quantity of milk in the stomach would be quite small and the air-bubble very large, lifting up the left half of the diaphragm. Then there would be a sudden contraction of the stomach followed by vomiting. In such a case if the infant was given more abundant nursings at longer intervals the air was expelled and replaced by the milk, and vomiting averted. Leven and Barret also noted another type of air-retention and vomiting, which they believed was due to a spasm of the cardia. The same phenomena were observed radioscopically as in the other type, except that the air was at no time expelled, and spasm of the cardia was deemed to be the cause. In order to lessen the intragastric tension, small but frequent feedings were employed.

Regarding the teaching in most training schools for nurses, that the baby should be kept in the horizontal position after nursing, Smith and Le Wald[13] state: "Air is swallowed with food by many if not all infants. The erect posture favors eructation of this air; the horizontal posture prevents it. The horizontal posture, by preventing eructation, is an important cause of vomiting, colic, indigestion and disturbed sleep." They, therefore, advise that the infant be held upright before and after feeding to encourage eructation of the air. Feeding should be given at as long intervals as possible, they believe, and each feeding should not be given too slowly.

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CHAPTER XVII

THE STOMACH AFTER OPERATION

Operations most commonly performed upon the stomach include gastrojejunostomy, gastroduodenostomy, sleeve resection, partial gastrectomy with gastro-enterostomy, pyloroplasty, gastrostomy, gastropexy, gastroplication and local resection of ulcers or tumor-bearing areas. After any of these interventions a roentgen examination is often advantageous in determining the functional behavior of the stomach and finding the cause of an occasional unsatisfactory result. When a gastrojejunostomy has been made, information is sometimes desired as to the exact site of anastomosis, the patency of the stoma and the general mechanical results of the operation. After a resection for cancer the question of a possible recurrence is of deep interest.

One of the most elaborate studies of the enterostomized stomach is that by Härtel,[1] who reports his findings in 22 cases. In several cases as the stomach was being filled with the bismuth meal, it was noticed that the ingesta lagged below the air-buble. Filling of the pyloric portion was often slower than normal. Before the stomach was completely filled, evacuation through the stoma commenced. In every case the contents passed rather freely through the anastomosis, and, in some cases, through the pylorus also. Emptying took place in from one to three hours. In 7 of the cases, the flow through the stoma was intermittent. In one case it was rhythmic and synchronous with inspiration. The periodic flow in the other cases corresponded to the peristaltic waves. Härtel believes that a peristaltic wave passing over the stoma tends to narrow it momentarily, and that this explains the intermittent outflow which by others has been ascribed to the new development of a sphincter-mechanism at the stoma. Owing to the rapid emptying of the enterostomized

stomach, it is rather difficult to determine its size as compared with that before operation. Most writers agree that there is a shrinkage. Härtel indorses this view and attributes it to an increase of tone, and thinks that the process takes place gradually in the course of several months. He did not observe any marked alterations of peristalsis.

From a study of 6 cases in which posterior gastro-enterostomy had been performed, and from a review of cases reported by others, Outland, Skinner and Clendening[2] conclude that gastro-enterostomy if properly done is a drainage operation, and that if the stoma is at the lowest part of the stomach in the erect position, the food leaves the stomach almost exclusively by the gastro-enterostomy opening, the stomach emptying with great rapidity. In cases in which the gastro-enterostomy does not quite drain the stomach, the food leaves both by the stoma and the pylorus.

Case[3] thinks that gastro-enterostomized stomachs may be divided into three classes:

1. Those with a very large gastro-enterostomy opening, the food dropping in an apparently passive way from the stomach into the small bowel. These patients, Case says, frequently complain of a sickening distress, especially after the ingestion of a meal consisting largely of warm liquid, and he attributes the distress to sudden overdistention of the small bowel.

2. The stomachs which do not empty well after the operation, probably not because the opening is too small, but because it is placed too high or too far from the pylorus. The stomach empties quickly until the level of the opening is reached, after which it empties very slowly, the residue at that time remaining for eight, ten or more hours.

3. The normally functioning cases—those patients in whom the passage of material from the stomach occurs very much as in the normal patient. A few moments elapse before food is seen in the jejunum, the passage of food boluses is irregularly intermittent, and the total time required for clearance of the opaque meal averages from four and a half to six hours.

Case found also that unless organic pyloric obstruction existed, it was the rule to find some of the barium passing through the pylorus as well as through the stoma. In several cases in which the pylorus was blocked by mattress sutures, it became patent again as early as the fifth or sixth week after operation. In 2 out of 4 cases in which pyloroplasty had been done, Case was able to confirm Cannon's and Blake's finding that too rapid exit of food from the stomach was prevented by the formation of rhythmically contracting constriction rings in the duodenum. At times he also noted analogous phenomena after gastrojejunostomy, namely, a sort of sphincter-action in the jejunum at a point 3 to 6 cm. below the gastrojejunal opening.

Obviously it is impossible to define closely the normal, expected and desirable conditions following operation. These will depend largely upon the particular case at hand, the nature and extent of the original lesion, and the character of the intervention, which is often controlled by circumstances rather than by choice. Yet some conception of what may be considered the normal sequences of operation is necessary for the judgment of abnormal results. Customarily, after a gastrojejunostomy I have observed the following:

1. The opaque meal passes freely through the stoma. This is the rule, with rare exceptions, even after the lapse of years. The flow through the anastomosis may be continuous, intermittent, or rhythmic. It is perhaps somewhat more voluminous and continuous shortly after operation than it is when months or years have elapsed, but the stoma does not tend to contract materially as time goes on.

2. Unless the pylorus is obstructed by the original lesion or was blocked at operation, a part of the gastric contents may pass through the pylorus spontaneously, or can usually be driven through it by manipulation. When the pylorus has been blocked at operation it may reopen within a few weeks or months. As a rule, even with a patent pylorus, the bulk of evacuation apparently takes place through the stoma.

3. There is no retention from the six-hour meal in the stom-

ach, duodenum, or jejunal loop. The stomach empties in considerably less time than the normal unoperated stomach. I am unable to endorse Case's theory that after gastro-enterostomy the stomach should empty preferably in normal time; this result would militate against the most common purpose of the operation.

4. The stomach is usually smaller than before operation, unless marked dilatation existed previously.

5. The stomach is not deformed as to its general contour (unless by the original lesion or its resection-scar), and has no tendency toward hour-glass form or spastic distortion.

6. The gastric contour at the stoma is not usually deformed except occasionally by a slight, smooth incurvation at that point.

7. Extensive adhesions about the stoma simply as a result of operation are uncommon, and the stomach is at least moderately mobile.

8. Peristalsis is not overactive. If there is any change at all, it would seem to be toward lessened activity.

9. The efferent jejunum is neither narrowed, dilated nor markedly irregular in outline.

10. The duodenum is not dilated.

Any departure from this summary should be viewed with mistrust, but should be carefully interpreted in conjunction with the surgical and clinical histories. Figs. 318, 319 and 320 illustrate presumably normal conditions following gastro-enterostomy, the roentgen examination showing no evidence of secondary pathology, and the patients having no symptoms demanding further surgery.

After a sleeve resection, the stomach, besides being diminished in size proportionately to the amount exsected, may also show more or less hour-glass contraction at the suture line, or an incisura at that point on the greater curvature (Fig. 321). In time such a constriction tends to become less pronounced. If only a small gastric sac remains as a result of the resection, its capacity gradually increases to some extent. Faulhaber and v. Redwitz[4] observed circular contraction at the site of a sleeve

FIG. 318.—Normal condition after gastrojejunostomy. Stoma at *s*. Meal leaving stomach chiefly through gastro-enterostomy, though some barium has passed the pylorus.

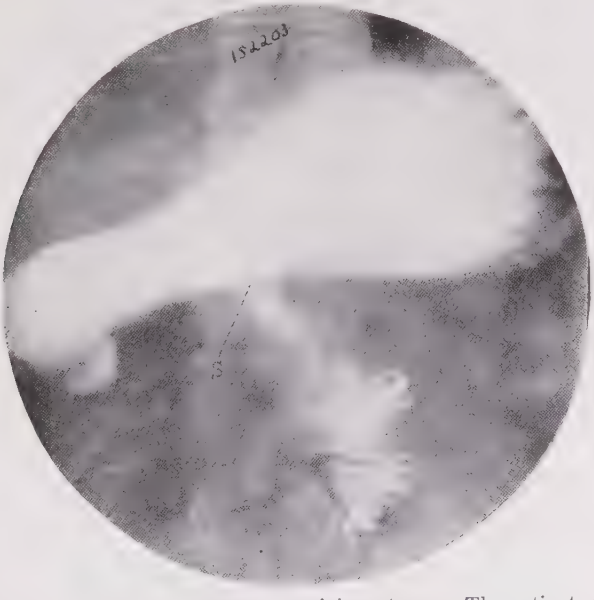


FIG. 319.—Normal condition after gastrojejunostomy. The patient was corpulent and the pressure of the abdomen, while the plate was being made, displaced the stomach upward into a transverse position. The undeformed stoma is seen at *s*. Pylorus patent.

FIG. 320.—Normal condition after gastrojejunostomy. Stoma at *s*. Small amount of barium passing into duodenum.

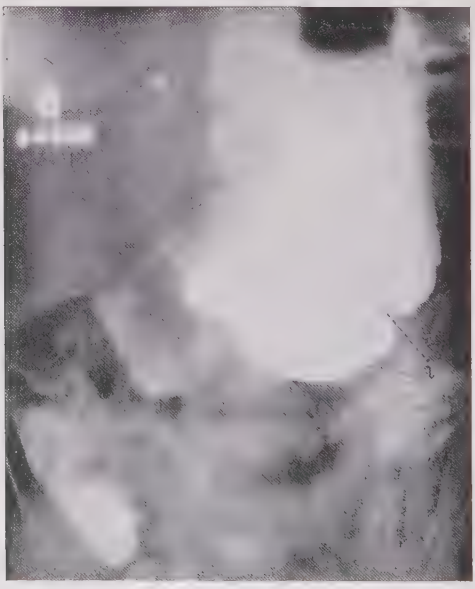


FIG. 321.—Stomach after sleeve-resection, showing contracture at point of anastomosis, *i*. (Other details of this case will be found in the chapter on Gastric Ulcer.)

resection, and this was associated with a small stomach which emptied rapidly through the pylorus.

Following an extensive ablation of the pyloric portion, closure of the duodenum and making a gastro-enterostomy, the remnant of the stomach shows as a small, vertically hanging pouch, with the stoma at the lowest point. Subsequently the pouch enlarges somewhat. It should be smoothly contoured, pliable and expansible, if all diseased tissue has been removed (Fig. 322).

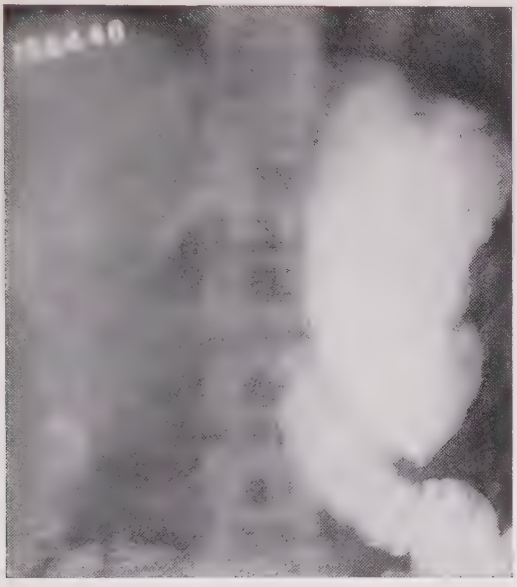


Fig. 322.—Stomach after resection, duodenal closure, gastro-enterostomy. Roentgenologically normal.

Pyloroplasty obliterates the normal constriction at the ring and the duodenal loop merges directly into the gastric cavity. Gastric drainage is copious and the evacuation-time is shortened.

The few cases of gastropexy (for ptosis) which I have examined did not show any roentgenologic signs of the operation.

Cohn,[5] in three patients upon whom gastrostomy had been performed, noted persistent hour-glass contraction at the site of the opening. Notwithstanding a notable lack of peristalsis the

gastric contents were rather rapidly and continuously evacuated through an open pylorus.

The roentgenologic determination of post-operative complications is not easy because of the inevitable physical and functional changes incident to operative intervention. To safeguard his conclusions, the examiner should be informed as fully as possible concerning the conditions found at operation, what was done, and the subsequent clinical history. Roentgenograms made prior to operation are especially valuable for comparison with those made after.

The important complications following gastric surgery include jejunal or gastrojejunal ulcer, so-called vicious circle, and recurrence or new development of cancer or ulcer. Concerning these the roentgen examination can often give fairly precise information. Besides these candidly pathologic conditions, unsatisfactory results are sometimes due to imperfect surgical technic. Since surgeons differ widely among themselves as to technical details, it is not in the province of the roentgenologist to decide whether or not a gastro-enterostomy opening is too large or too small, too high or too near the pylorus, or whether the afferent jejunal loop is of proper length. But the x-ray should show the site of the stoma, its patency, and, with an unobstructed pylorus, the length of the afferent loop. Final judgment in these matters may be left to those directly concerned.

JEJUNAL AND GASTROJEJUNAL ULCERS

Ulcers developing in the vicinity of the stoma after gastrojejunostomy have been variously designated jejunal and gastrojejunal ulcers. A post-operative ulcer situated in the jejunum well away from the gastro-enterostomy opening, is, strictly speaking, jejunal. An ulcer involving the stoma, both on its gastric and jejunal aspects, is more properly described as gastrojejunal.

The first gastrojejunal ulcer was observed by Braun[6] in 1899 some eighteen years after Wölfer's[7] first gastro-enterostomy.

Paterson[8] was among the first to draw attention to these ulcers, and in his comprehensive article collected 51 cases from the literature.

Haberer[9] found that jejunal ulcer is most likely to follow blocking the pylorus. The x-ray method of diagnosis was only used in two of Haberer's cases and was of little value. In all of his cases the characteristic symptoms of the ulcer began to appear from one to one and a half years after operation. He believes that the older the gastro-enterostomy the less likely is the development of gastrojejunal ulcer because the jejunum has become accustomed to the acid gastric juice. In seven of his cases the jejunal ulcer was immediately over the gastro-enterostomy at the mesenteric insertion of the jejunal loop used for the anastomosis. One ulcer was in the afferent loop; in two cases it was in the efferent loop, some distance from the stoma. In Haberer's ten cases the stoma itself was free from pathologic changes. He has never found a case following resection.

In Guérin's[10] three cases pyloric ulcer with obstruction was the primary lesion for which the gastro-enterostomy was done. The symptoms developed within from one year to eighteen months after the anastomosis was made. Although the symptoms were not characteristic they made the diagnosis fairly easy because they suggested duodenal rather than stomach trouble. In two cases the x-ray examination showed signs of gastric retention. In the third case it demonstrated contraction of the stoma. While Guérin believed that the roentgen signs were fairly conclusive in his three cases, he feels that they may not always be so definite.

Wright[11] states that the occurrence of jejunal and gastrojejunal ulcer following gastro-enterostomy is a serious drawback to an otherwise valuable operation. This statement is hardly in accord with our experience since we feel that it is a rare complication and should not deter the surgeon from doing a gastro-enterostomy when the indications are definite. Since the use of absorbable suture material, first used in the clinic by C. H.

Mayo in Jan., 1916, the incidence of these ulcers has been 1.1 per cent., which is certainly very small for an operation that otherwise gives such excellent results.

Wright has met with three cases in the last twelve months, two in patients of his own and one in a patient of another surgeon. Duodenal ulcer was the primary lesion for which the gastro-enterostomy was made.

In Wright's first case the ulcer was just beyond the stoma. In the other two cases the ulcer involved the anastomosis; they were in reality gastrojejunal ulcers. He emphasizes the action of imperfectly inactivated gastric contents on a mucosa which is not accustomed to withstand gastric digestion and which is more powerful when hyperacidity is present as an important factor in the causation of gastrojejunal ulcer. The x-ray was not employed in any of his cases as a diagnostic aid.

Zollschan[12] reports three cases. One was confirmed by necropsy, the other two cases were not. In the first case, a forty-eight-year-old patient, a gastro-enterostomy was done for gastric ulcer in 1909. The roentgen examination could not be fully carried out because of the patient's weakness. However, a niche could be seen on the lesser curvature. A second large niche, very painful on pressure, was opposite the inferior end of the cardiac sac of the stomach, in the region of a palpable resistance, and slightly to the left of the functionating gastro-entero-anastomosis. It contained a residue six hours after the meal. Closer examination left no doubt that this second niche was associated with the jejunum and was interpreted as very probably a peptic jejunal ulcer.

The second case, a thirty-six-year-old patient had been operated on in 1912 for duodenal ulcer, and a posterior gastro-entero-anastomosis retrocolica, was made. The patient was well until Dec., 1916, when he began to have the usual trend of symptoms. Five hours after the opaque meal was taken a residue was observed just below and to the left of the umbilicus. A second meal showed it to be extraventricular, lying to the left of the efferent loop of the jejunum, consisting of three dis-

tinct layers: an opaque lower layer, a second lighter layer above this, and third a gas-bubble. This spot was resistant and intensely painful on pressure. Zollschan believed this case to be analogous to the first, which was established by necropsy.

The third case, a thirty-six-year-old patient, had a gastroenterostomy made in 1915 for ulcer at the pylorus. In February, 1917, the roentgen examination revealed an opaque spot to the left of the umbilicus, lying outside the stomach, and very painful to pressure. This opaque spot represented an ampulla-like dilatation of the efferent loop of the jejunum immediately below the anastomosis.

To sum up, these cases demonstrated the following roentgen signs: Retention from the six-hour meal, circumscribed extraventricular point painful on pressure in the region of the first loop of the jejunum behind the anastomosis, impaired peristalsis, failure to visualize the Kerkring folds, and ampulla-like distention in the neighborhood of the anastomosis.

Richardson[13] reports two cases of jejunal ulcer. In the first case the x-ray was not used except for postoperative study. At operation considerable induration was formed about the stoma and especially of the jejunum. The stoma was still open, was about 2.5 cm. in diameter and on account of the induration around it was readily palpable. Directly opposite the stoma, at the apex of a fold of the jejunal loop, was a deep ulceration, 19 mm. in diameter extending through all the coats into the mesentery.

In Richardson's second case pre-operative roentgen findings suggested gall-stones. There was no definite evidence of duodenal ulcer. Operation disclosed an ulcer on the anterior wall of the duodenum. The gall-bladder was negative. A posterior isoperistaltic gastrojejunostomy was done. Nine months later the patient began to have trouble. The x-ray examination gave the following: Gall-bladder negative for stones. Barium meal showed the stomach to be emptying through the gastroenterostomy. No barium was seen passing through the pylorus and first part of the duodenum. The stomach itself was normal,

with extremely short emptying time. There was a definite ileal stasis.

Operation.—The whole gastro-enterostomy felt thickened and indurated. An ulcer 3 by 9.5 mm. just to the jejunal side of the line of union on the right anterior aspect of the stoma could be seen.

Bottomley in discussing this paper said that most cases had too little postoperative supervision and that gastrojejunal ulcer never follows gastro-enterostomy for cancer of the stomach.

Other cases of jejunal and gastrojejunal ulcer have been reported by W. J. Mayo,[14] Moynihan and Tatlow,[15] Mayo Robson,[16] Soresi,[17] and others.

In 1915 the writer, in collaboration with Balfour[18] collected 14 cases from the records of the clinic, and since then 55 additional cases have been under treatment. In 25 of these 69 cases the primary operation had been done elsewhere. All of the ulcers were of the gastrojejunal type, and this term shall be used in subsequent discussions. All postoperative ulcers in the neighborhood of the stoma, whether involving it or not, have presumably similar causes, and have like symptoms, so that their designation is immaterial.

Butsch,[19] working in the Mayo Clinic found that in 3480 operations for ulcer of the gastro-intestinal tract from Jan. 1, 1906, to Jan. 1, 1919, 3175 were for duodenal ulcer and 305 for gastric ulcer. Three thousand one hundred and sixty-one cases (99.5 per cent) of the operations for duodenal ulcer were posterior gastro-enterostomies; 14 were anterior. No gastrojejunal ulcer followed the anterior gastro-enterostomies.

In the gastric ulcers operated on there were 279 posterior gastro-enterostomies and 26 anterior gastro-enterostomies. In the total 3480 cases posterior gastro-enterostomy was done in 3440 (98.8 per cent); anterior gastro-enterostomy was done in 40 cases (1.1 per cent). Of the 44 cases following primary operation in the clinic, 38 followed gastro-enterostomy made for duodenal ulcer, while 6 followed gastro-enterostomy for gastric ulcer. There were 1.1 per cent of the total number of posterior gastro-

enterostomies that developed gastrojejunal ulcer, a very small percentage when the frequency of the operation is considered. When the pylorus was blocked this percentage was increased to 5 per cent. There was also a slight rise in those cases in which perforation had occurred—1.5 per cent.

The incidence of gastrojejunal ulcer as in duodenal ulcer and gastric ulcer is comparatively much higher in the male, nearly 4 to 1.

The etiology of these ulcers is still a moot question. An important factor appears to be the use of unabsorbable suture material in making the anastomosis; silk or linen sutures being found at the site of the ulcer in many instances. Other factors may be the acid gastric juice coming in contact with an alkaline bathed jejunum, and faulty operative technic, such as trauma, poor coaptation and interference with the blood supply. However, these ulcers have also occurred after the use of absorbable suture material and the Murphy button.

Pathologically, they are usually of considerable surface extent, with much induration and hyperemia. The line of anastomosis is usually involved, but the ulcer tends to spread further on the jejunal than on the gastric side. Adhesions were present in the majority of our cases.

Clinically, they do not give rise to any symptoms or signs which can be considered definitely diagnostic. After a variable period of relief by the gastro-enterostomy, the patient again develops pain and other symptoms, often somewhat like those prior to operation, but without any fixed and decisive complex. Any aid to the discovery of these ulcers is, therefore, of distinct value. The results in our own cases convince me that by the roentgen-ray such aid can be obtained, and that in many instances the condition can be positively diagnosed.

Postoperative ulcers perforated into the colon have previously been given passing mention by roentgenologists, but simple gastrojejunal ulcers have not heretofore been extensively studied from the roentgen viewpoint. Mathieu and Savignac[20] state that in jejunal ulcer perforated into the large bowel, the

direct passage of bismuth into the colon can be demonstrated. They state further that the colon may be narrowed by adhesions about the fistula, and the small intestine may be dilated in all or parts of its length, which conditions are susceptible of demonstration by roentgenoscopy. Their remarks seem to be based largely on 5 cases of jejunocolic fistula reported by Lion and Moreau.[21] One of these was examined with the roentgen-ray by Béclère. Moynihan and Tatlow's case of gastrojejunal ulcer was rayed by Rowden, but his report was noncommittal.

Barsony[22] reports a case of gastrojejunal ulcer in which the roentgen-ray showed a pocket at the line of anastomosis, the size of a kroner. Some five hours later the pocket was still filled with bismuth after the stomach was empty. Barsony lays strong emphasis on the persistence of bismuth in the ulcer-cavity as a characteristic. But, excepting one of the cases hereinafter reported, I have not noted any roentgenologic evidence of a cavity resembling the niche of penetrating gastric ulcer or the accessory pocket of perforated ulcer. The nature of the ulcer rather precludes any probability of visualizing its crater as a niche, for the reason that the ulcer is most often characterized by surface area rather than depth.

In a series of 69 cases in the Mayo Clinic examined by the roentgen-ray, all were of the non-fistulous type, and the majority showed distinct signs of secondary pathology. These manifestations included deformity about the stoma, narrowing and deformity of the efferent jejunum, diminished patency of the stoma, dilatation of the stomach, retention from the six-hour meal, hyperperistalsis, dilatation of duodenum, and spasticity of the stomach.

Deformity about the stoma of a posterior gastro-enterostomy is sometimes not readily visible. If the point of anastomosis is well up on the vertical portion of the stomach, it may be shown by an oblique view, but if it is located on the horizontal part of the stomach or about the juncture of the vertical and horizontal sections an oblique view is of little service, and it has often been advantageous to lift up the overhanging lower border

of the stomach and thus expose the anastomosis. With a high anterior or posterior gastro-enterostomy a lateral view may be of value. While a gastro-enterostomy often produces a little dimpling at the point of attachment, there is ordinarily no marked irregularity. On the other hand, in approximately four-fifths of the cases of gastrojejunal ulcer, rather striking deformity about the stoma was observed. Gastrojejunal ulcer following an anterior gastro-enterostomy sometimes produces a palpable inflammatory mass which corresponds to the visible irregularity and filling-defect about the stoma. This finding is almost pathognomonic. Since a gastro-enterostomy is often in the median line, pressure against the spine may deform this part of the stomach, and the examiner should be careful in his interpretation of plate findings. The patient's abdomen should not be pressed too tightly against the plate, and, if he is plated in the prone position, his chest and shoulders should be supported by cushions, or a table with a deep fenestrum for the plate should be used. However, if the distortion about the stoma is marked and identical on all plates the observer is safe in saying that it is abnormal.

Narrowing of the jejunum and deformity of its contour was present in more than half the cases of gastrojejunal ulcer. It involved the efferent limb, usually quite near the stoma. To be of value, this sign must be definite and constant at the screen inspection and on all plates.

A lack of free patency of the stoma was notable in several instances. The signs of this condition are both direct and indirect.

Directly, the examiner can note the lessened amount of barium passing out, in contrast to the normal copious exit. If the flow is scant or wanting in spite of manipulation of the gastric contents toward the stoma, it is reasonably certain that the opening is not free. If originally made ample, contraction of the orifice, though unusual and somewhat indicative of gastrojejunal ulcer, is not absolutely so. In one case a narrowing was found at operation but without any evidence of ulcer.

However, in this instance the stoma, though narrow, was not deformed.

Indirectly, obstruction may be manifested by a retention from the six-hour meal, or by the large size of the stomach. Gastric hyperperistalsis, or dilatation of the duodenum or afferent limb of the jejunum, may also be in evidence. Of these signs the six-hour retention is most important. Occurring in a gastro-enterostomized stomach, it is highly significant of obstructed drainage. In most of the cases of retention in association with gastrojejunal ulcer, the retention was between the stoma and pylorus. In one case the barium rest was in the immediate neighborhood of the stoma, as though held in a small pouch. This proved to be a gross ulcer with a jejunal pocket of considerable size, being exaggerated by adhesions. The unresected enterostomized stomach, even though large before operation, tends to contract to normal or even smaller dimensions. If then it does not show diminution in size, but is still large, interference with its emptying may be suspected. Another common sequence of obstruction is an exaggeration of peristalsis. An increase in the vigor and number of the waves may also result from other causes, so that this sign is merely indicative of some abnormal condition. Dilatation of the duodenum was observed in six cases, and this may or may not have been due to obstruction by the ulcer at the stoma.

Lessened mobility of the stomach was noted in ten instances, and was the result of extensive adhesions about the stoma. But this is a sign of which the observer can rarely be confident, especially when dealing with a posterior gastro-enterostomy. By palpation, changing the position of the patient, and requiring him to breathe deeply, fixation at the point of anastomosis can sometimes be fairly determined.

Spasticity of the stomach, with extensive irregularity of the gastric borders was noted in five cases; this cannot be considered very significant, except as an indication of reflex irritation.

In translating these signs into a diagnostic opinion, the examiner should be fully acquainted with the entire clinical and

surgical history of the case, not for the purpose of anticipating the roentgen findings, but to prevent hasty deduction from them. The roentgen phenomena of gastrojejunal ulcer fall into two groups—those broadly denoting an abnormal condition, and those pointing directly to the seat of trouble. Six-hour retention, hyperperistalsis, large size of the stomach, dilatation of the duodenum, and spasticity of the stomach, are included in the first group. They may be noted singly or in varying combinations. The second group includes deformity about the stoma, narrowing and irregularity of the jejunum, scant flow of barium through the gastro-enterostomy opening, and fixation of the stomach at the site of anastomosis. All these point to the latter as the pathologic focus, and here gastrojejunal ulcer is by far the most common lesion. After resection of the stomach for cancer, similar signs may result from recurrence of the growth at the point of gastro-enterostomy; the history should aid in making the distinction. Peculiarities or errors of surgical technic may also produce some of the roentgenologic manifestations enumerated above, and in view of this possibility, the roentgen diagnosis of gastrojejunal ulcer should be guarded.

Case 160,721, a man, aged 35 came for examination March 3, 1916, complaining of gas on his stomach and fullness after meals. His appetite was good, but he was obliged to stop eating before hunger was completely satisfied. The bloating and flatulency was severe at times and was relieved only by vomiting. The trouble recurred in spells and usually lasted five or six weeks, with freedom during intervals of from three to four months. The patient did not eat when in pain, and had not tried soda for relief. Pain usually came two or three hours after meals. There was no hematemesis or melena; no urinary, cardiac, or pulmonary trouble. Total acidity 48, free HCl 38. Weight satisfactory. Roentgen examination showed the stomach negative; no six-hour rest; the duodenal bulb was deformed. Diagnosis: Duodenal ulcer (Fig. 323). At operation, June 3, 1916, small duodenal ulcer was found 2.5 cm. below the pylorus. A posterior gastro-enterostomy and appendectomy were done. The patient returned Aug. 24, 1916. At this time the roentgen findings were, irregularity of contour about the stoma; gastro-enterostomy not freely patent; pylorus free. Diagnosis: Gastrojejunal ulcer (Fig. 324). Operation

was done Sept. 23, 1916, and a gastrojejunal ulcer was found. The stomach and intestinal openings were enlarged and the gastro-enterostomy restored. The ulcer was found at the left angle of the stoma

Fig. 323.

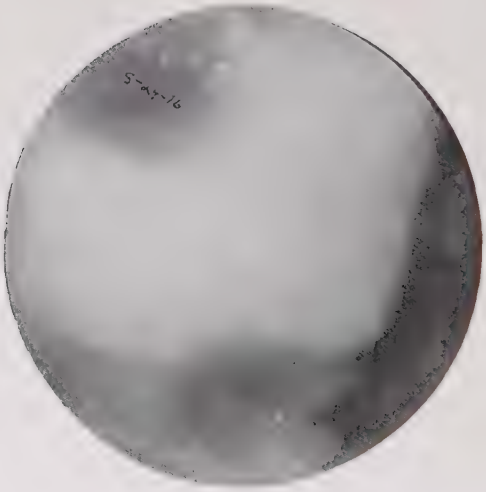


Fig. 324.

The ulcer in the duodenum was apparently the same as at the time of the former operation. The patient again returned with symptoms Nov. 14, 1917. The x-ray showed deformity about the stoma; there was no obstruction. A diagnosis of gastrojejunal ulcer was made for

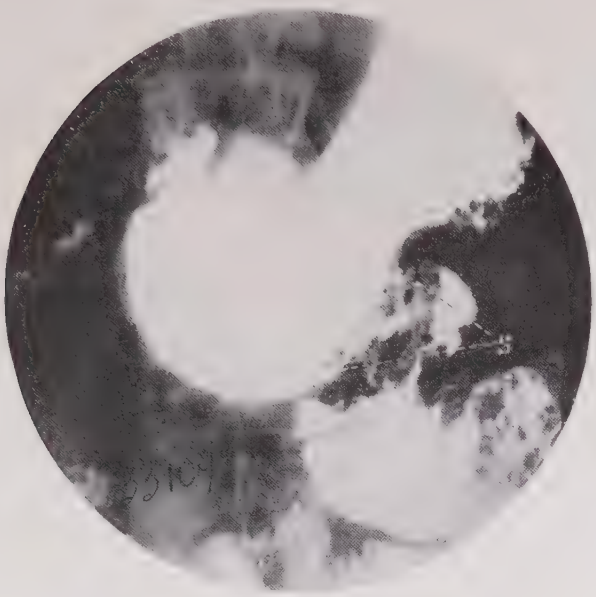


FIG. 325.—Case 33,109. Gastrojejunal ulcer. Irregularity of stoma and jejunum shown at *s*.

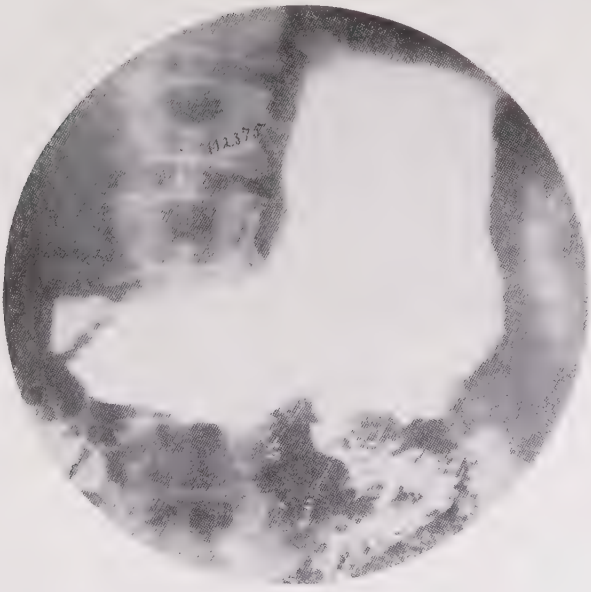


FIG. 326.—Case 112,375. Gastrojejunal ulcer. Deformity about stoma at *s* Narrowed jejunum, *j*.

the second time, and operation a month later showed a gastrojejunal ulcer situated in the right angle of the gastro-enterostomy.

Case 33,109, male, aged 51. Stomach trouble for the last twelve years. Pain localized to pit coming on two or three hours after eating; relieved by food. Three or four spells a year lasting three or four weeks at a time. Some nausea; vomits frequently. Total acidity, 58; free HCl, 44; combined, 14. Food remnants, 1. Clinical diagnosis: Duodenal ulcer. Operative findings: January 18, 1910. Large contracted ulcer duodenum. Operation: Posterior gastro-enterostomy.

Fig. 327.—Case 96,667. Gastrojejunal ulcer. Deformity of stoma at *s*. Narrowed jejunum, *j*. Note hyperperistalsis; peristaltic waves at *p*.

Subsequent history: June 8, 1915. Following operation the patient was well for five years; then there was an onset of same complaint, coming with the change in the weather for several days at a time. Pre-meal distress and food-ease. Condition has progressed rapidly; distress almost continuous; vomiting of retained food. Weight loss from 162 to 126. No urinary disturbance. S.B.P. 118, D.B.P. 80. No masses felt, rectal shelf free. Total acidity, 28; free HCl, 20; combined 8. Roentgen findings: Retention one-fourth the six-hour motor meal. Irregularity of stoma and jejunum. Pylorus not freely patent; gastro-enterostomy only moderately so. Diagnosis: Gastrojejunal ulcer (Fig. 325). Operative findings: Very large gastrojejunal ulcer,

partly in the stomach and partly in the jejunum. Pylorus adherent to abdominal wall. Linen suture found hanging in the ulcer. Operation: Separation of gastro-enterostomy. Opening in stomach closed Excision of ulcer. Jejunum reunited. Gastroduodenostomy.

Case 112,375, male, aged 42. In January, 1914, gastro-enterostomy elsewhere for duodenal ulcer, following excision of ulcer and closure of pylorus. After the operation the patient had a great deal of distress.

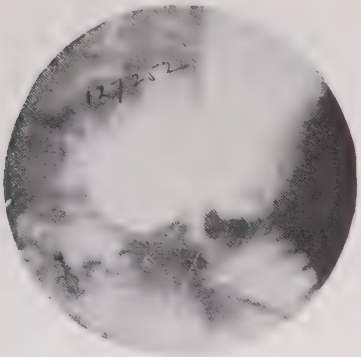
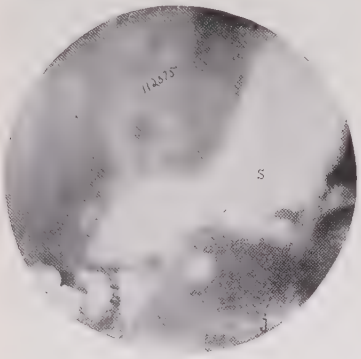


FIG. 328.



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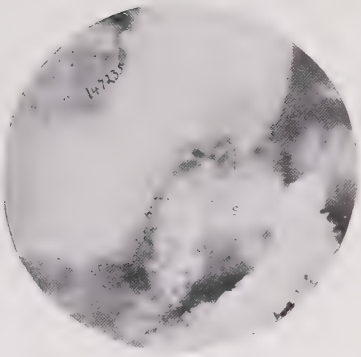

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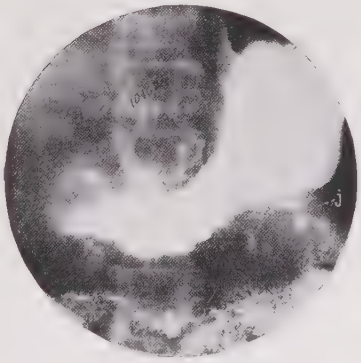

FIG. 331.

FIGS. 328, 329, 330, 331.—Cases of gastrojejunal ulcer. Stoma, *s*. Jejunum, *j*.

In August, 1914, he visited the Mayo Clinic, at which time an indeterminate (post-operative) diagnosis was made. After leaving the clinic he returned to his work, but the distress became so severe that his surgeon operated again in October, 1914, and found adhesions in the neighborhood of the stoma with a mass at the gastrojejunal juncture and a linen thread hanging in it. About one week after this operation a large abscess formed in the wound, which has continued

to discharge from time to time. In probing the wound, the linen thread was removed. Roentgen findings: No retention from the six-hour meal. Filling-defect about stoma and efferent jejunum (Fig. 326). Operative findings: Gastrojejunal ulcer in which was hanging

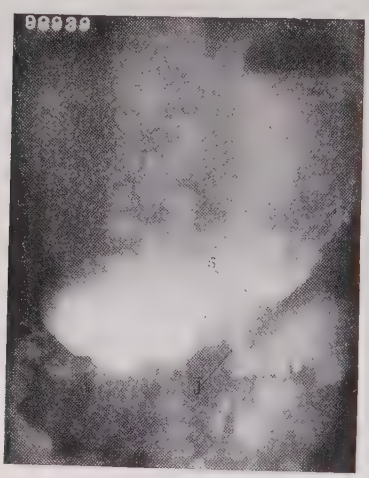

Fig. 332.

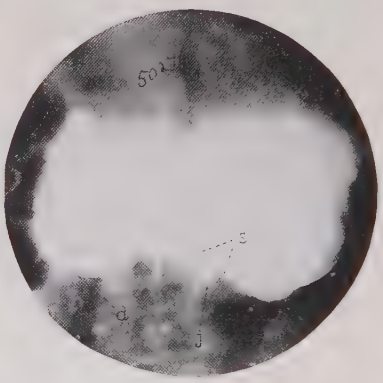

Fig. 333.

Fig. 334.

Fig. 335.

Figs. 332 to 335.—Cases of gastrojejunal ulcer. Stoma, *s*. Jejunum, *j*. Gastric ulcer, *u*. Hour-glass stomach, *h*. Duodenum, *d*.

a piece of linen thread 20 cm. Ulcer involved wall of transverse colon, but had not perforated into it. Sinuses communicating with abdominal wall. Operation: 1. Reunion pyloric end of stomach and

FIG. 336.

FIG. 337.

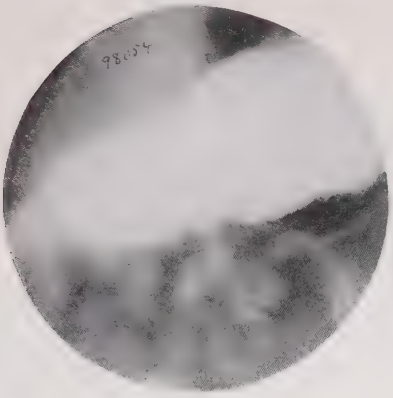

FIG. 338.

FIG. 339.

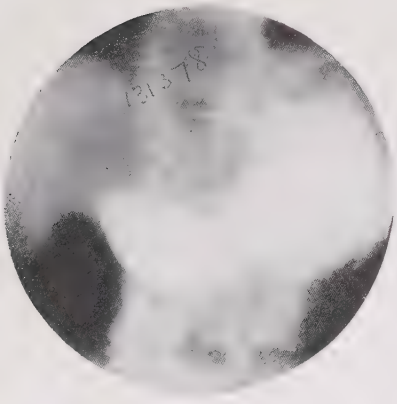

FIG. 340.

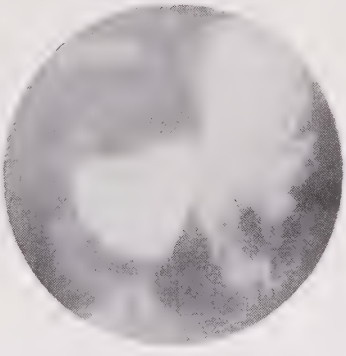

FIG. 341.

FIGS. 336, 337, 338, 339, 340 and 341.—Cases of gastrojejunal ulcer showing deformity of anastomosis.

body by plastic. 2. Divulsion of stricture of the duodenum. 3. Gastro-enterostomy cut off. 4. Restoration of jejunum.

Case 96,667, male, aged 51 years. With the exception of a violent pain lasting for a few minutes some twenty years ago, followed by epigastric soreness and jaundice, the patient had always been well until twelve years ago, when a period of intermittent stomach trouble developed, lasting for a couple of years. These attacks were usually accompanied by epigastric distress coming on two or three hours after eating, with food-ease. For the last nine years, more or less constant complaint with pain two to four hours after eating and early part of night, eased by soda, food, vomiting, and occasionally by lavage. Hemoglobin, 65 per cent. Reds, 3,540,000. Urine negative. Wassermann negative. Total acidity, 80; free HCl, 52; combined, 28. Roentgen findings: Fairly large stomach. No retention from the six-hour motor meal. Hyperperistalsis; deformity of the bulbus duodeni. Diagnosis: Duodenal ulcer. Operation: December 12, 1913. Perforating duodenal ulcer. Gall-bladder and appendix negative. Posterior gastro-enterostomy. Subsequent history: Patient returned October 5, 1914, stating that he had been comfortable for three months, then began to have occasional sharp pain and vomiting. During past three months, trouble almost constant. Roentgen findings: Large stomach with retention one-half the six-hour motor meal. Hyperperistalsis; gastro-enterostomy not functionating well. Deformity of stoma (Fig. 327). Operation: October 12, 1914. Finney operation on jejunum for jejunal ulcer at old gastro-enterostomy opening. Ulcer caused by old linen suture hanging in gastroenterostomy opening.

REGURGITANT VOMITING AND VICIOUS CIRCLE

Persistent regurgitant vomiting after gastro-enterostomy, the vomit usually containing more or less bile, is the principal symptom of what is commonly designated "vicious circle." Shortly after operation there is sometimes regurgitant vomiting, which ceases after lavage or other treatment, but a persistence of this vomiting, which rarely occurs, is indicative of mechanically obstructive conditions requiring reintervention.

Moynihan[23] classifies four varieties of misdirected current, any one of which establishes the circulus vitiosus:

1. Regurgitation of duodenal contents through the pylorus.
2. Escape of fluids from the stomach into the afferent loop.

3. Escape of fluids from the afferent loop into the stomach. This is generally considered the most frequent and the most grave variety.

4. Regurgitation of the contents of the efferent loop into the stomach.

As to the causes of regurgitant vomiting, Moynihan cites the following suggestions by Chlumskij:[24]

"1. Formation of a spur. This is certainly the most frequent. When the anastomosis is effected, the two limbs of the loop hang downward, and a sharp kink with spur-formation results at the point of junction.

"2. The jejunal displacement may cause a kink at the duodenojejunal juncture, and thereby produce an acute obstruction of the duodenum.

"3. The mucous membrane of the stomach may form large pouting valves which obstruct the afferent opening.

"4. Closure of the anastomotic opening if the muco-mucous stitch is improperly applied.

"5. Compression of the efferent branch of the loop by the colon (Doyen).

"6. Stendel related a case operated upon by Czerny, in which the opening in the transverse mesocolon had narrowed and constricted the efferent loop.

"7. In the original operation of Wölfler, the antiperistaltic implantation of the jejunum favored regurgitation."

Moynihan himself believes that the mechanical defect consists mainly, if not solely, in leaving a loop of jejunum between the flexure and the anastomosis. The loop becomes distended, "water-logged," and thus obstructive. Besides the foregoing possible and proven causes, Finsterer[25] mentions others, including an unduly long afferent loop, which, when filled, compresses and obstructs the efferent limb. He also emphasizes still another cause, namely, herniation of the small intestine through the slit in the mesocolon, thus compressing and obstructing the afferent jejunum. He reports an instance of this in which the roentgen examination showed a long loop of the upper small

bowel distended with barium to the size of a child's arm, and confirming the diagnosis of stenosis.

During the past six years I have examined by the roentgen-ray 30 cases of regurgitant vomiting following gastro-enterostomy, all of which were reoperated. With two exceptions, the original operation had been performed elsewhere. The time that had elapsed since operation ranged from one month to ten years, with an average of three years. In twelve of these cases the roentgenologist did not report any definite evidence of secondary pathology. Some of the examinations were made early in this work when the examiner was satisfied with determining the patency of the stoma and pylorus, and was dubious of obtaining any additional information. It is noteworthy also that in some cases of regurgitant vomiting a second surgical exploration fails to reveal an adequate cause, especially in those cases which have had a gastro-enterostomy performed for the relief of symptoms and without demonstrable pathology. Many surgeons deem these latter cases to be particularly prone to post-operative troubles.

In ten of the cases the roentgen examination elicited abnormal signs, which in most instances were indicative of grave disturbance. In the main, the signs were those of obstruction, as shown by retention from the six-hour meal, large size of the stomach, failure of the barium to pass through the stoma, and hyperperistalsis. At reoperation various conditions were found. In three instances the obstruction was due to adhesions. In one case the stricture was apparently produced by contraction of the opening through the gastrocolic omentum, and in another case the gastro-enterostomy had been made on a long loop which had kinked. Brief details of four cases follow:

Case 105,429, man, aged 39 years. Chronic indigestion since the age of ten. Attacks one to two months apart, lasting up to ten days, consisting of fullness, distress, and sour eructations, coming irregularly after meals, and with irregular food relief. In later years a sore spot at the right of the ensiform was present in the attacks. Six years ago he had a gangrenous appendix removed, and was quite well for two

years. Then the old trouble recurred daily until three months ago, when he had an acute attack of pain and was operated upon the next morning. A posterior gastro-enterostomy (no loop) was done for what was believed by his surgeon to be a duodenal ulcer. For eleven days following the operation he vomited large quantities of yellowish fluid every half hour. After this the vomiting came every five to ten days, each time vomiting large amounts of duodenal content. At present he can only take about 180 gm. of food at a time; if more is taken, regurgitant vomiting follows. Roentgen findings: No retention. Rather high gastro-enterostomy. The roentgenogram (Fig. 342) shows a very large amount of barium in the afferent loop of

FIG. 342.—Case 105,429.

the jejunum, while very little is seen in the efferent limb. Where the mechanical conditions are normal, the reverse is true. Because of these findings, a diagnosis of vicious circle was made. Findings at operation: Large gastro-enterostomy opening; pylorus patent. Many adhesions in upper abdomen. No ulcer could be found, either in stomach or duodenum. Operation: Gastro-enterostomy cut off.

Case 133,498, man, aged 51. Posterior gastro-enterostomy a month previously for duodenal ulcer with impending perforation. (This had been diagnosed roentgenologically on hyperperistalsis and six-hour retention.) He now complains of vomiting bitter, green fluid,

at times slate-colored. The vomiting occurs mostly from 9.00 p.m. to 1.00 a.m. Total acidity, 38, free, 24; combined, 14; food remnants; filtrate 1,000 c.c. Roentgen findings: Large stomach with retention of half the six-hour motor meal. Irregular vigorous peristalsis. Nothing seen passing through stoma. Some barium passing pylorus (Fig. 343). Findings at reoperation: Stoma greatly strictured, apparently by contraction of the opening through the gastrocolic omentum.

Case 37,378, man, aged 47. Gastro-enterostomy one year ago, following which he vomited incessantly for ten days. Since then he

FIG. 343.—Case 133,498. Details described in text.

has continued to vomit frequently, often daily for several days. Remissions at times of several days without vomiting. The vomiting occurs usually some hours after eating, and is fluid in character, food being ejected only occasionally. Gastric analysis: Total acids, 36, free, 26; combined, 10; raisin-skins. Roentgen findings: Large stomach. Retention of half the motor meal. No evidence of gastro-enterostomy. Deformity of the duodenal bulb. Dilatation of third portion of duodenum (Fig. 344). Findings at reoperation: The gastro-enterostomy had been made on a 10 cm. loop, turned to the right. Duodenal ulcer 1.5 cm. below the pylorus (Enterostomy—Finney).

Case 141,212, man, aged 61. The patient gave a history of having had a gastric ulcer excised nine years ago, and a gastro-enterostomy two years ago for subsequent pyloric stenosis. After the second operation he did very well until six months ago, when he began to have occasional projectile vomiting. This has gradually become more marked, and for the past three weeks he has been vomiting every other day. Weight loss marked. Gastric analysis: Total acidity, 14; all combined; food remnants (raisin-skins); filtrate 1000 c.c. Roentgen findings: Retention of three-fourths the motor meal (Fig. 345). No

Fig. 344.—Case 37,378. Description in text.

barium between stoma and pylorus. Gastro-enterostomy obstructed (Fig. 346). Findings at reoperation: Large gastric ulcer between stoma and pylorus, which had contracted until the stoma was almost closed. (Resection pyloric end; plastic enlargement of gastro-enterostomy. On microscopic examination of the resected tissue, cancer cells were found.)

RECURRENCE AND NEW DEVELOPMENT OF LESIONS AFTER OPERATION

The roentgenologic demonstration of new and recurring lesions after operation is sometimes feasible, as instanced by the following cases:

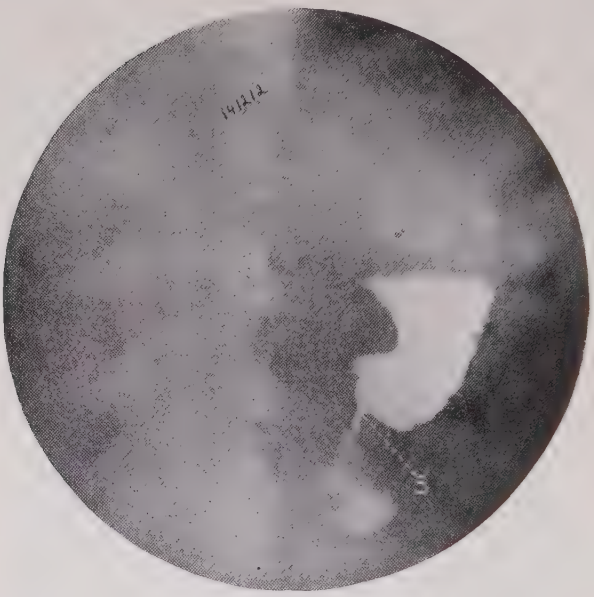

Fig 345.—Case 141,212. Six-hour retention in stomach. Narrowing of stoma at *s*.

Fig. 346.—Case 141,212. Same case as in Fig. 343, after filling stomach.

Case 89,460, man, aged 64. Resection, with anterior gastro-enterostomy one year ago for extensive carcinoma of the lesser curvature of the stomach, perforated. The patient gained 25 pounds in weight and felt well until five months ago. He now has heavy distress after meals and is again losing weight. Total acidity, 10; all combined. Roentgen findings: No retention. Filling-defects at site of resection (Fig. 347). Diagnosis: Recurring carcinoma; inoperable.

Case 75,677, woman, aged 47. Resection three-fifths of stomach with anterior gastro-enterostomy for cancer of the pyloric end of the stomach, one year ago. Gained weight and felt well until three

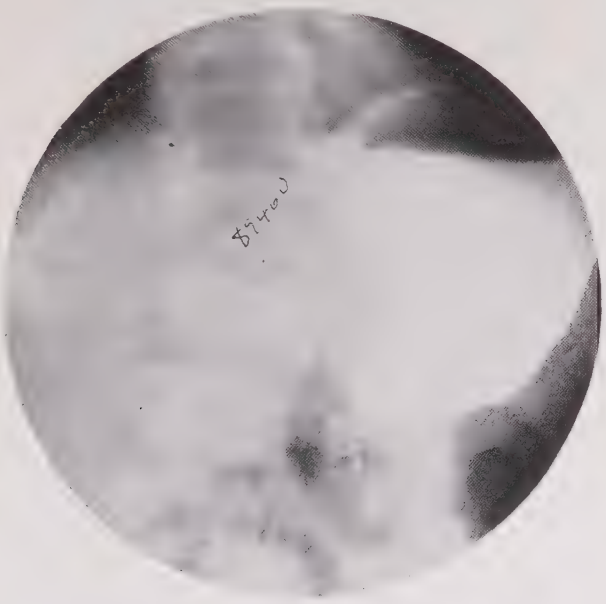

Fig. 347.—Case 89,460. Recurring carcinoma of the stomach after resection.

months ago. Since then bitter regurgitation, occasional vomiting, and loss of appetite and strength. Resistance and tenderness in right epigastrium. Roentgen findings: No retention from six-hour meal. Filling-defect at site of resection corresponding to palpable mass (Fig. 348). Diagnosis: Recurring carcinoma. No operation.

Case 124,629, man, aged 44. Mikulicz-Hartman-Polya resection, three-fourths of stomach, end-to-side anastomosis, for cancer involving all of stomach except cardiac end, nine months ago. Now complains of poor appetite, distention after meals and weight loss. Roentgen findings: No retention. Finger-print-like filling-defects extending up

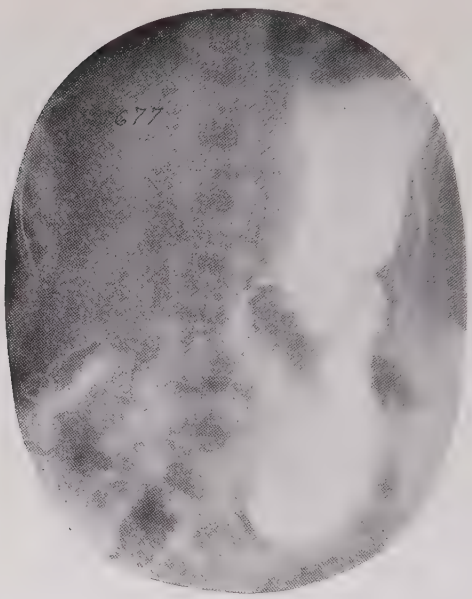

FIG. 348.—Case 75,677. Recurring gastric cancer

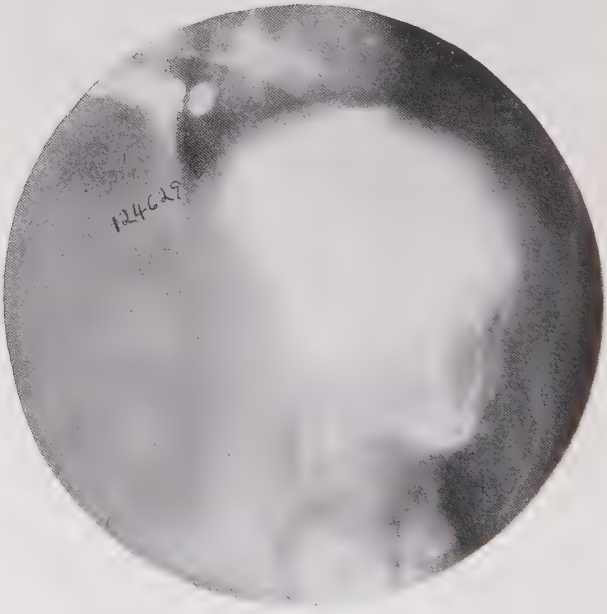

FIG. 349.—Case 124,629. Recurring cancer.

FIG. 350.—Case 81,588. Cancer following ulcer. Filling-defect at *f*. Efferent jejunum at *j*.

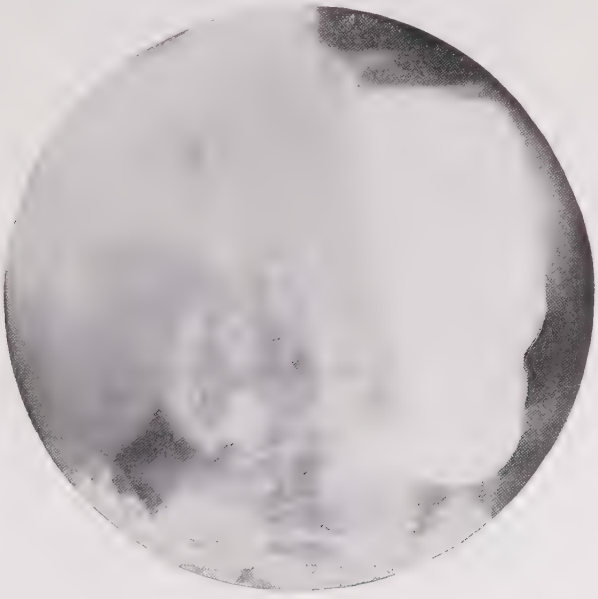

FIG. 351.—This patient had had a resection of the pyloric end of the stomach four years previously for carcinoma on ulcer. The roentgenogram, which shows a filling-defect on the lesser curvature above the stoma, is indicative of a recurrence. However, no corresponding mass could be felt and the patient's general condition was good. In the absence, therefore, of any clinical corroboration it was thought that possibly the filling-defect was the result of the operation. A reëxamination after a few weeks or months would determine the matter.

FIG. 352.—Patient had had a V-resection of an ulcer on the greater curvature, body of stomach. The roentgenogram was made four weeks after the operation. The stomach, especially the pyloric segment, is small and the greater curvature is irregular, probably the result of the operation, and not of any new pathology.

FIG. 353.—Gastero-enterostomy for obstructive, non-resectable cancer of the stomach.

ward from site of resection (Fig. 349). Diagnosis: Recurring cancer; inoperable.

Case 81,588, man, aged 41. Posterior gastro-enterostomy seven months previously elsewhere, for ulcer of the lesser curvature just above the pylorus, also ulcer on the greater curvature extending into the duodenum. He had no trouble after the operation except an occasional heaviness, until three months ago, when he began to have regurgitation of food at night. About four weeks ago he commenced

Fig. 354.—Case 81,479. Posterior gastro-enterostomy three years previously for gastric ulcer, lesser curvature. The roentgenogram shows extensive filling-defects on both curvatures, due to the development of cancer. The jejunal loop is shown in its entirety.

to have severe epigastric pain from midnight until morning, belching of gas, and sour eructations. Roentgen findings: Gastro-enterostomy freely patent. No retention from the six-hour meal. Filling-defect lesser curvature (Fig. 350). Diagnosis: Lesion of the stomach. Findings at exploration: Inoperable carcinoma of the lesser curvature with glands of large size as high as the diaphragm. Pancreas enlarged.

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CHAPTER XVIII

GALL-STONES AND DISEASE OF THE GALL-BLADDER AND LIVER

GALL-STONES

The degree of precision with which gall-stones can be diagnosticated by the roentgen-ray is a debatable question. Although efforts to demonstrate biliary calculi began early in the history of roentgenology, the first trials were either unsuccessful or succeeded so rarely that the method was deemed impracticable. Even as early as 1899, Carl Beck,[1] of New York, who was perhaps the first to report such an achievement, exhibited a roentgenogram depicting biliary and hepatic calculi. With the gradual advance of roentgenologic technic the attempt to show gall-stones was frequently renewed and was more often rewarded by positive findings. Still, the percentage of demonstrations has, in the main, been discouragingly small, and the rank and file of roentgenologists have had little cause for enthusiasm. Lately, the roentgenography of gall-stones has been given fresh impetus by such men as Pfahler, Case, Cole and George.

Pfahler,[2] who was among the first in this country to take up the matter, concluded from his experiments on the cadaver in 1901 that the roentgen method was useless and unreliable. In 1914, however, Pfahler was able to find stones in 20 out of 27 operated cases, or 74 per cent. Nevertheless, he believes that in general one cannot count on more than 50 per cent. being demonstrable. Technically, he places the patient on the abdomen with the plate under the gall-bladder region. The patient's arms are extended and the upper part of the body is bent strongly to the left (not rotated). The tube (6 or 7 Benoist), with compression-cylinder diaphragm, is set so that the rays will pass obliquely through the space between the last rib and the crest of the ilium toward the gall-bladder, compression being

made if desired. He prefers short exposures, but without the intensifying screen, and agrees with Rubaschow[3] that several exposures are generally necessary with different tubes and different timing. Careful oblique illumination of the finished plate is usually necessary to bring the shadows into view.

Case[4] believes he is safe in the opinion that when gall-stones are present they can be demonstrated in 40 or 50 per cent. of the cases. He prefers to look for them in the course of an examination of the digestive tract with the bismuth meal, rather than make a special examination.

Cole[5] notes that during the last few years several roentgenologists have detected gall-stones in about 50 per cent. of the cases examined, but that this percentage was estimated in different ways by different men. Cole regards catharsis and fasting as an essential preliminary to plating. Among other details favored he mentions stereoscopic plates, and double-screened plates (two plates, back to back, with intensifying screens of different speeds, in the same holder). Superimposing finished plates and thus deepening the stone-shadows assists interpretation.

George and Leonard[6] believe that 85 to 90 per cent. of gall-stones can be shown. They emphasize the use of an extremely small cone, but are indifferent as to the employment of intensifying screens. They regard preliminary catharsis with its resulting gas as a more disturbing factor in interpreting plates than the fecal contents of the colon.

Caldwell[7] says: "If we only make enough plates and make them well enough, we can obtain suspicious shadows in the gall-bladder region of any normal individual. The interpretation of gall-stone plates, therefore, becomes a matter involving not only skill and judgment, but temperament as well. In no other field of roentgen diagnosis is the personal equation of the observer more important. This, I believe, is the best explanation of why some observers report as high as 85 per cent. and others as low as 5 per cent. of successes in these examinations. The greatest danger of the x-rays is in faulty interpretation. These faults

usually consist in reading into the plates something which is not there. The clinical indications of gall-stones are fairly accurate, and it is likely that stones are present in at least 50 or 60 per cent. of those cases submitted to x-ray examination. Of these perhaps as many as one-tenth give perfectly definite, reliable x-ray shadows of gall-stones. In the other nine-tenths of the cases examined, some of the x-ray plates will show hazy and suspicious shadows, many of which are due to gall-stones. If we consider all these hazy and suspicious shadows corroborative evidence of gall-stones, the operation will vindicate us in the majority of the cases, and we may easily overestimate the help actually obtained from the x-ray plates. We must be very careful lest the clinical knowledge we have of the patient may lead us to accept as evidence of gall-stones x-ray shadows such as might be found in some of the x-ray plates of any normal individual." He therefore warns against regarding as proof of gall-stones "any x-ray shadow that does not present characteristics distinguishing it definitely from other shadows, and which has not the sharpness of outline commonly found in other calculi."

My own figures do not compare favorably with the larger percentages quoted above, notwithstanding the fact that abundant material has been at my disposal. Many of the cases gave typical histories, but even in these, although extraordinary efforts were made, it was possible to obtain diagnostic shadows in only a small minority. The difficulty has been, not to find shadows, for these were often present, but to find shadows that seemed definite and characteristic. The personal equation of an observer is not open to argument, and sincere endeavors to advance roentgenologic diagnosis should not be disparaged. On the other hand, a degree of conservatism is usually wholesome and corrective. Taking the more cautious estimate of 50 per cent. of successes as possibly attainable, the examiner may doubt whether a strenuous effort to find gall-stones is worth while, since if he does not succeed, the chances of their presence or absence remain practically as before. However, he is not

justified in taking this attitude, even though his failures far outnumber his successes. But, unless he is unusually fortunate, he should keep in mind two things: First, that though he may fail to find their shadows, stones may nevertheless be present, and a negative roentgen finding should be ignored; second, that stones are incidental and not essential to a cholecystitis which may necessitate surgery. C. H. Mayo[8] has said: "We must remember that infection is the entity and gall-stones are secondary to it; that although gall-stones can often be shown in a radiograph—surely a great help—the latter cannot show the severe infections, the papillary cholecystitis, soft stone or inspissated bile. Largely to depend upon it as now developed, would be to step back twelve years in the advance of gall-bladder and gall-duct surgery and diagnosis." In this connection it may be stated that of the gall-bladders operated upon in the Clinic, 30 to 35 per cent. contain no stones.

Factors affecting the demonstrability of gall-stones include their composition, size, number, and situation, their enveloping medium, the amount of obscuration by liver-tissue, the thickness of the patient, the thoroughness of his preparation and the roentgenographic technic.

Pure cholesterin stones have slight density and are most difficult to show. The mixed type of stones, containing cholesterin, bilirubin and calcium salts, are most common, and their density is proportionate to the amount of contained lime. Stones made up almost wholly of lime salts cast the deepest shadow, but these are relatively rare, comprising probably less than 1 per cent. of the total. Large stones, even though poor in calcium, and numerous small stones massed together may sometimes be shown (Fig. 355).

Bile has considerable absorptive power for the rays, and stones immersed in this medium are less plain in proportion to the amount of bile. It is perhaps for this reason that stones in the cystic or common duct can be shown more readily, as is claimed, than those in the gall-bladder (Figs. 356 and 357). In occasional instances, stones in the gall-bladder are less opaque

than the surrounding bile, as can be easily shown by raying gall-bladders which contain bile and stones, after surgical removal (Fig. 358).

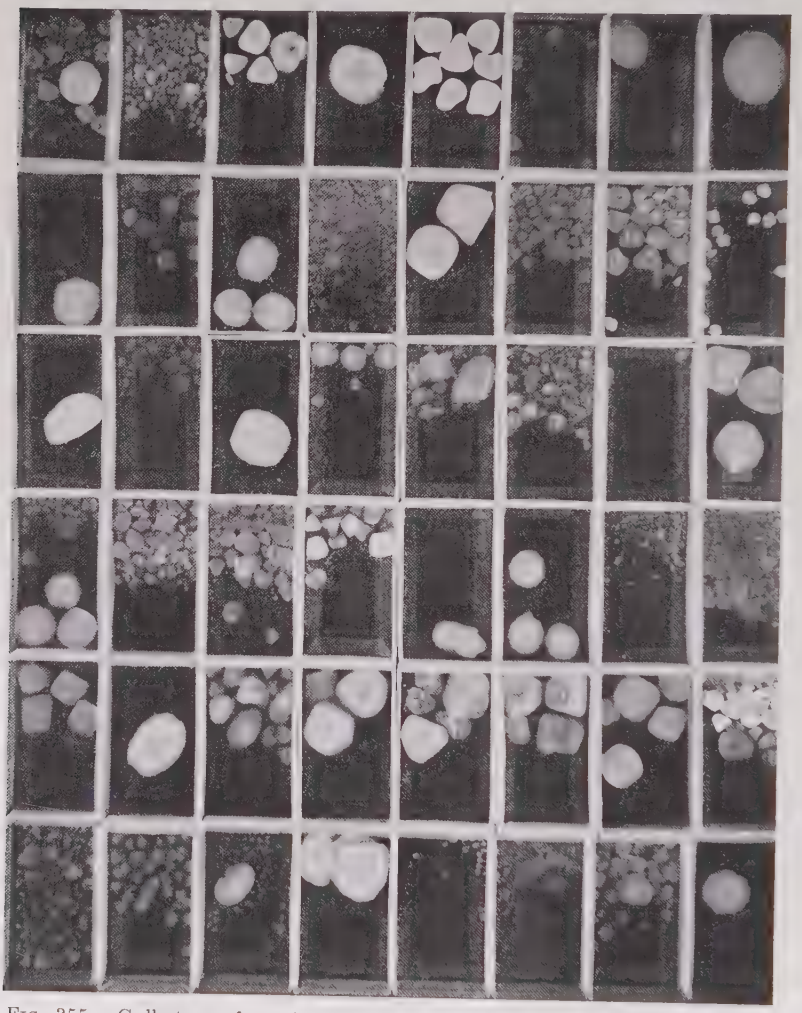

FIG. 355.—Gall-stones from forty-eight different cases. After removal the stones were put into small pasteboard boxes and roentgenographed on a single plate. Note the variability of size and density of the shadows.

The density of the liver-tissue, by obscuring the shadows of stones, is a serious obstacle to their detection, and numerous technics have been devised to minimize this difficulty. The

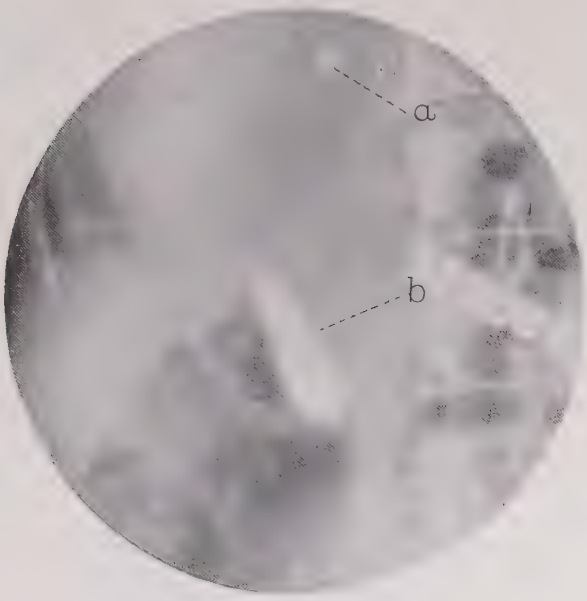

FIG. 356.—*a*, Stone in the cystic duct. *b*, Stone in the long pendulous gall-bladder.

FIG. 357.—Arrow indicates stone in the common duct.

thick belly of corpulent individuals, who frequently have gall-stones, is an added hindrance to satisfactory roentgenography.

Technic.—While in rare instances the shadows of large calcareous stones can be seen fluoroscopically, plating is almost invariably necessary for diagnosis. As indicated in the foregoing citations, roentgenographic methods differ. Notwithstanding the objection quoted, a preliminary clearing out of the intestinal canal has obvious advantages. Hence, it is preferable

Fig. 358.—Stones in the gall-bladder. The roentgenogram was made after the gall-bladder had been removed intact, with its contained stones and bile. The stones are seen as dark areas lying in the more opaque bile.

to have the patient purge himself with castor oil or a saline, and fast prior to the examination. It is my custom also to make this examination before giving an opaque meal, the shadows of which may be confusing, although I have incidentally noted stone-shadows after the barium meal had been given. For plating, various positions have been advised. To avoid as much as possible of the liver-shadow, many operators lay the patient on the belly and direct the rays through the gall-bladder region obliquely downward, using compression. The tube placed

vertically over the plate often gives equally satisfactory definition. After trying numerous different angles it is impossible to say that any one is superior. The cone undoubtedly gives sharper images. Plates should be made during suspended respiration to avoid blurring by movement. The intensifying screen also helps to avert this by shortening the exposure time. On the other hand, the intensifying screen, if it happens to be imperfect, increases the danger of artefacts. It has been customary to make a few unscreened plates also. It is essential that the tube be of moderate vacuum, inclining to softness rather than hardness, and overexposure should be shunned. Occasionally the colon is inflated before the plates are made, employing for the purpose a Politzer bag and rectal tube. In a few instances the air-distended hepatic flexure made a background upon which the stone-shadows stood out distinctly. Probably the most important technical recommendation is the making of many plates, varying the penetration and exposure-time, for it is notorious that of two plates of apparently equal excellence, one may show distinct shadows while the other reveals no trace of them.

The opinion that if shadows of stones appear they will usually be found between the eleventh and twelfth ribs or slightly below the twelfth is erroneous. In the majority of our cases the stone-shadows were situated much lower, ranging from the level of the first lumbar vertebra to that of the fourth lumbar. The configuration of the costal arch varies to such an extent that the ribs are not always satisfactory landmarks. Besides, the gall-bladder itself is subject to some variation of position. The examiner should, therefore, not limit his search for stone-shadows to the classic field, but should carefully scan the entire right abdominal region and even as low as the iliac crest. The most characteristic appearance is that produced by the grouped shadows of multiple stones, showing like a bunch of grapes. Occasionally the facets can be distinguished. These shadows are not usually as dense as those of the large olive-shaped stones, which are often single, and sometimes show concentric laminæ.

Shadows of gall-stones must be differentiated from those of renal calculi. The latter are usually branched or irregular and of greater density than gall-stones, thus casting a more intense shadow (Fig. 359). Differentiation can be made by plates showing good detail which outline the kidney by stereo-roentgenograms, and by pyelography after the injection of sodium bromid (Figs. 360, 361 and 362). Plates made from back to front show gall-stones with better definition than renal calculi, while plates

Fig. 359.—Comparison of renal and biliary calculi. The kidney stones are seen above the line.

made from front to back bring out the kidney-stones more plainly. It is commonly stated that gall-stones lie further from the vertebræ than do renal calculi, but in both instances the relation of their shadows to the spine is variable. Indeed, gall-stones may lie so near the vertebral column (Fig. 363) that slight rotation of the patient may obliterate their shadow in that of the vertebræ. Calcified lymph nodes may be mistaken for gall-stones, but the former seldom show in clusters, and are often irregularly shaped (Fig. 364). Deposits of lime salts in the ribs

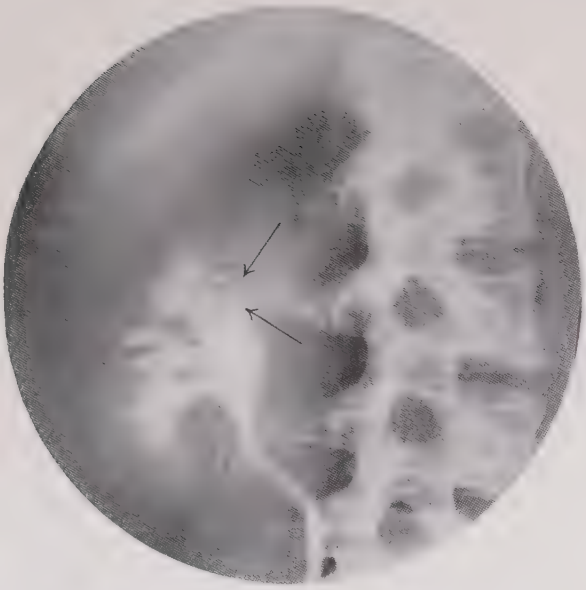

FIG. 360.—Renal calculus excluded by pyelogram. The annular shadow of the gall-stone is pointed out by the arrows.

FIG. 361.—Renal calculi excluded by pyelogram, *p*. Kidney outline, *k*. Gall-stones at *s*.

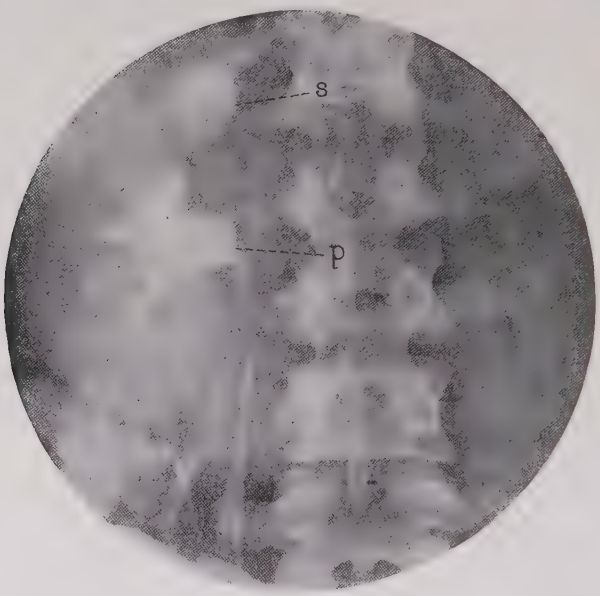

FIG. 362.—Large, single gall-stone at *s*. Injected kidney at *p*.

FIG. 363.—Cluster of faceted gall-stones, indicated by arrow, very near vertebral column.

generally show irregular streaking, and are directly in line with the rib-shadow. Desmoid tumor of the right rectus abdominis muscle (Fig. 365), fecaliths and fecal matter in the intestine may exceptionally produce shadows somewhat resembling those of gall-stones, and for this reason the bowel should be thoroughly evacuated beforehand. In addition to these sources of error, inexplicable shadows (Fig. 364) are often seen which by an active exercise of the observer's imagination can be interpreted

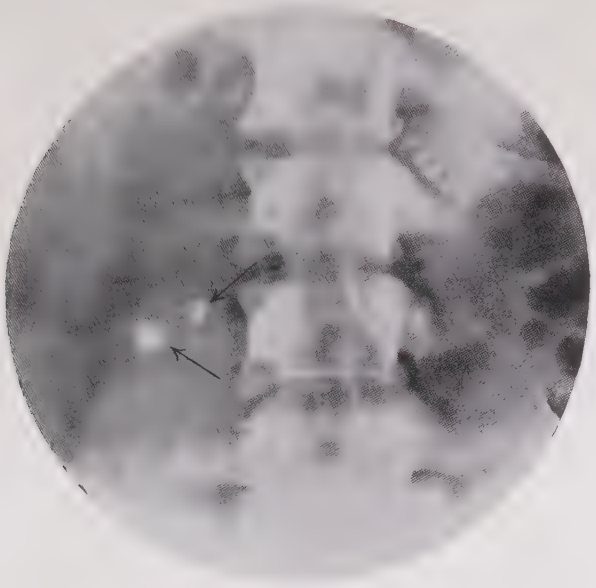

Fig. 364.—Calcified lymph glands indicated by arrows.

as being due to gall-stones. In every doubtful case a reëxamination should be made. Atypical and uncertain shadows should never be considered too seriously whether clinically substantiated or not.

Case 133,413, female, aged 47 years. Twelve-year history. Fullness and heaviness after meals relieved by vomiting, usually induced, rarely spontaneous. Always some soreness in region of liver and ascending colon. Much gas. Regurgitates bitter fluid. Apples and fats cause distress. Never definite colic; never jaundiced. Total acidity 10, all combined. Roentgen findings: Shadows of multiple small stones. The low position of these shadows, in the ilio-sacro-

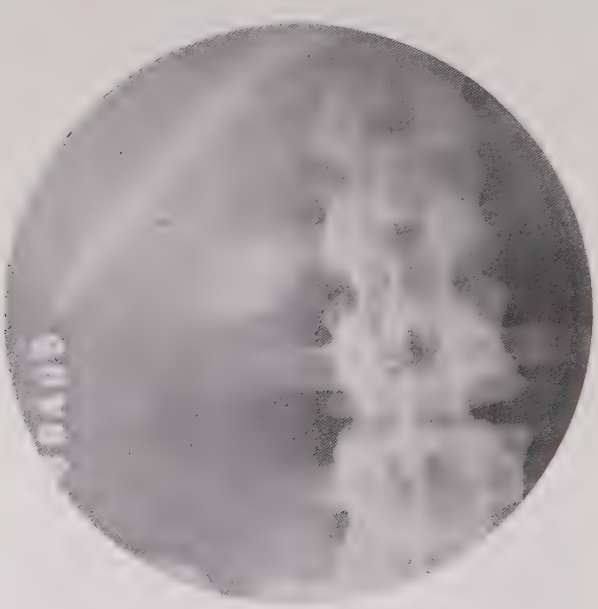

FIG. 365.—Shadow in the gall-bladder region. Because of its atypical character a pyelogram was made to exclude a renal calculus. This being excluded, the shadow was thought to be a gall-stone. At operation it proved to be a desmoid tumor of the right rectus abdominis muscle.

FIG. 366.—Case 133,413. The arrow points to the stone shadows.

lumbar angle, as shown in the roentgenogram, Fig. 366, is noteworthy. The case illustrates the variable position of the gall-bladder and the necessity of searching the entire right abdomen for shadows in suspected cases. Findings at operation: Cholecystitis with multiple small stones (Cholecystectomy). Pathologist's report: Chronic catarrhal cholecystitis. Cholelithiasis.

Case 140,266, female, aged 34 years. History of gastric distress and vomiting by spells, since childhood. Seven years ago, during about two months, she had attacks of severe pain at the right costal margin, and beneath shoulder-blade, lasting one or two days. For a

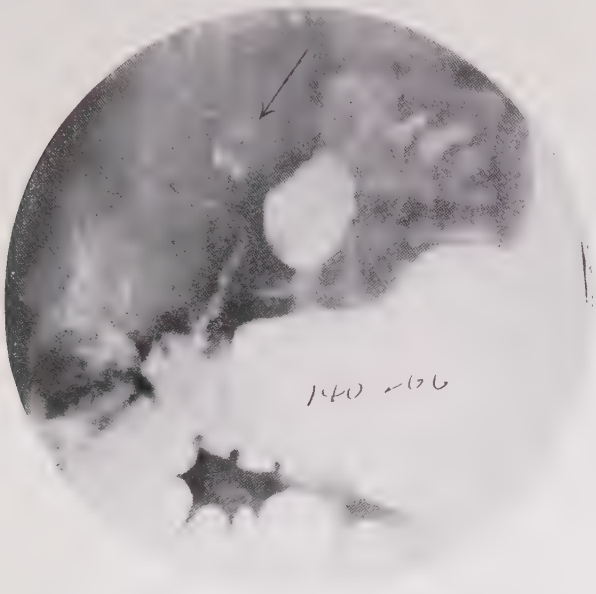

FIG. 367.—Case 140,266. Shadow of a single gall-stone marked by the arrow.

year past she has been having epigastric pain a half to two hours after meals, with occasional vomiting. Much epigastric soreness. Total acidity 74; free 64; combined 10; filtrate 500 c.c. Roentgen findings: Shadow of a single stone slightly above and to the right of duodenal bulb (Fig. 367). This shadow was visible also during the roentgenoscopic examination, its density being due to the fact that the stone contained considerable calcium. Findings at operation: Gall-stone obstructing neck of cystic duct (Cholecystectomy). Pathologist's report: Edematous chronic cholecystitis (old empyema with stone in cystic duct).

Case 86,771 (Roentgen-ray number 22,624), female, aged 21 years. The patient states that she has had pain and tenderness in the right abdomen for a number of years. An appendectomy three years ago gave relief for a few months. A year and a half ago she began vomiting, and for seven months she has vomited after almost every meal. She first has a sense of uneasiness and epigastric fullness after the meal; then vomits in a half to one hour. The gastric contents are ejected without nausea. Every few days at irregular times the patient has rather sharp pains at the right costal margin, radiating to the back, relieved by heat and by vomiting. She has never required morphia for the pain, and has never been jaundiced. Total acidity 66, all combined. Roentgen findings: Multiple, small, characteristic, annular shadows of gall-stones (Fig. 368). These were first discovered accidentally in making a roentgenogram of a duodenal tube *in situ*. Their visibility and the number shown were increased by inflating the colon. Findings at operation: Numerous stones in gall-bladder. Gall-bladder, liver, duodenum and pyloric end of stomach adherent in one mass with transverse colon and anterior abdominal wall (Cholecystectomy).

Case 152,564, female, aged 51 years. For fifteen years she has had attacks of pain in right hypochondrium, lasting two or three hours. At present she complains of constant pain in the right abdominal area unless she takes medicine. Icterus now and in former attacks. Total acidity 72; free 60; combined 12. Roentgen findings: Shadows of two large gall-stones (Fig. 369). Findings at operation: Two large stones in gall-bladder (Cholecystectomy). Pathologist's report: Chronic catarrhal cholecystitis with partial destruction of mucosa. Cholelithiasis.

DISEASES OF THE GALL-BLADDER

In lesions of the gall-bladder without discoverable stones the roentgen-ray can only exceptionally furnish decisive evidence. The gall-bladder itself, when it contains inspissated bile, or its walls are thickened or calcified, occasionally casts a shadow if the patient is not too thick and other circumstances are favorable (Fig. 374). Otherwise, the roentgen manifestations of cholecystitis are quite insufficient to support a diagnosis alone, although they may have some indirect and contributory value. Most of these indirect signs are obtained in the course of a

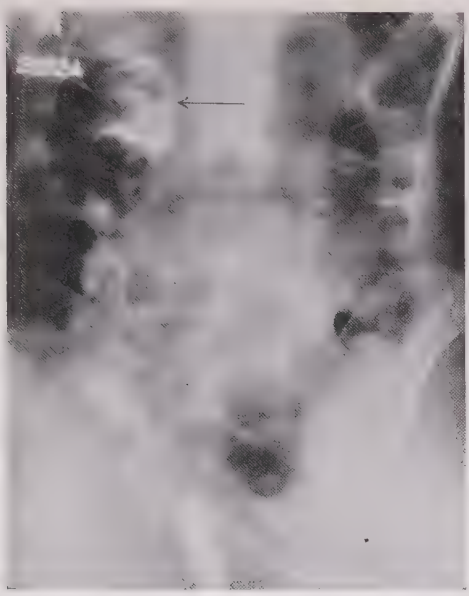

FIG. 368.—Case 86,771. Stone shadows marked by arrow.

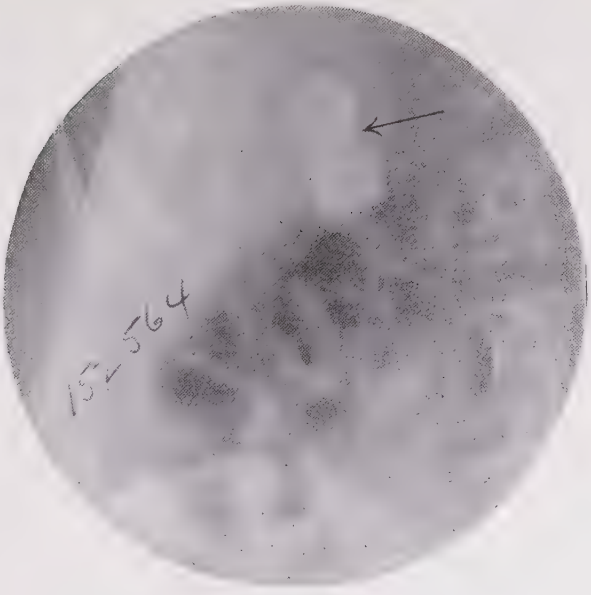

FIG. 369.—Case 152,564. Arrow marks shadows of stones.

routine examination of the digestive tract, and include the following:

1. Gastric spasm.
2. Six-hour residue in the stomach or duodenum.
3. Fixation of the pyloric end of the stomach, duodenum or hepatic flexure.

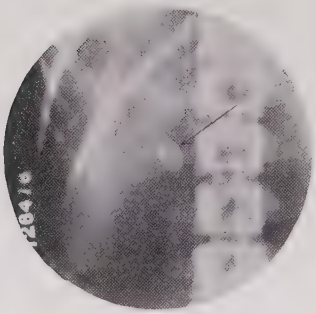

Fig. 370.

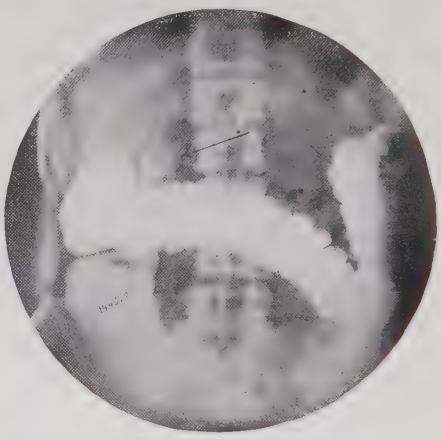

Fig. 371.

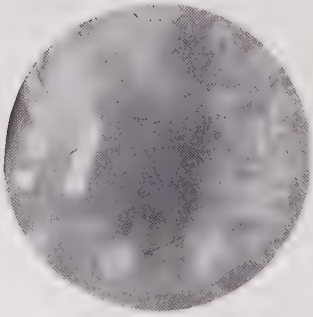

Fig. 372.

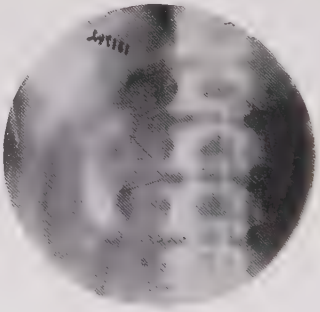

Fig. 373.

Figs. 370, 371, 372, 373.—Illustrative cases of gall-stones.

4. Drawing of the stomach to the right by adhesions, or displacement to the left by an inflammatory mass about the gall-bladder.
5. Increased gastric peristalsis.
6. Demonstration of Riedel's lobe of the liver.
7. Localization of a tender point over the gall-bladder area.

FIG. 374.—Lime-encrusted gall-bladder. Probe passed into gall-bladder through discharging sinus.

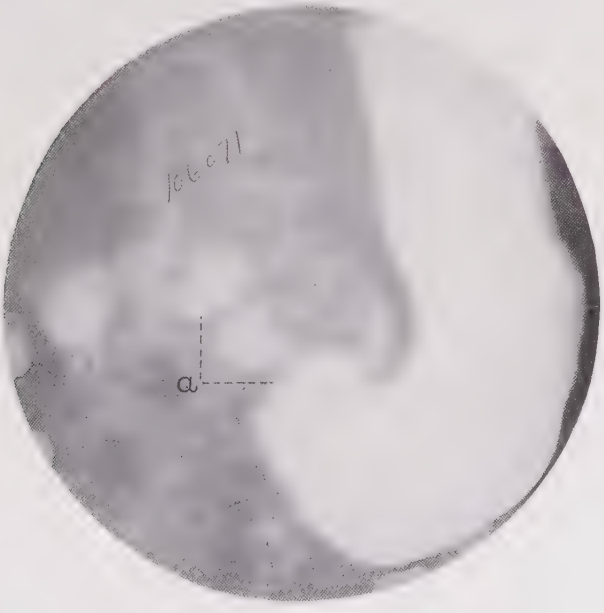

FIG. 375.—Gastrospasm, localized to pyloric end of stomach, *a*. This type of gastrospasm is frequently associated with disease of the gall-bladder. In this instance cholecystitis was found at operation.

8. Demonstration of an organically normal stomach and duodenum, and thus excluding them as probable causes of the symptoms.

As mentioned elsewhere (see "Gastrospasm"), spasms of the gastric musculature occur frequently in association with cholelithiasis, cholecystitis and pericholecystitis—so frequently that the gall-bladder should be suspected first of all whenever spastic

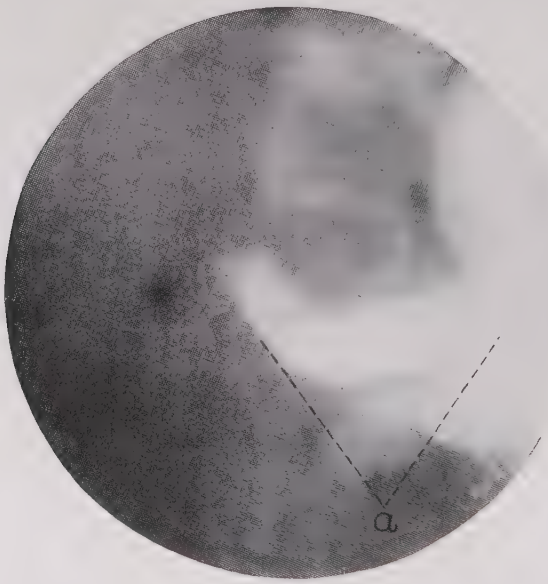

FIG. 376.—Spasm of the pars pylorica, *a*. Disease of the gall-bladder the only lesion found at operation.

eccentricities of the stomach are noted (Fig. 375). The spasmodic manifestations in the stomach may be slight or extensive, ranging from a transient incisura or a temporary hour-glass to a regional spasm with considerable deformity. An especially striking type of the latter is that in which the entire pars pylorica is contracted to a narrow, stiffened, sometimes palpable, tube (Fig. 376).

A six-hour residue in the stomach or duodenum may occur as a result of pericholecystic adhesion-bands constricting the pylorus or duodenum. Again, a gastric residue may be found,

although rarely, in association with cholecystitis but without any organic obstruction.

The pyloric end of the stomach may be fixed and its contour roughened by adhesions. The duodenum, especially the bulb, may likewise be deformed or stenosed. Adhesions may fix the hepatic flexure of the colon to the pylorus or duodenum so that they cannot be separated by manipulation.

Adhesions about the gall-bladder may, though rarely, draw the stomach to the right, and if they obstruct the duodenum,

FIG. 377.—Indentation of pyloric end of stomach at *d* by gall-bladder.

the pars pylorica may be somewhat expanded and bulbous. On the other hand, a distended gall-bladder, or an inflammatory mass about it, may indent the pars pylorica or bulb (Fig. 377), or displace it to the left. The mass may be palpable and either mobile or adherent to the abdominal wall. Exceptionally, such masses may be carcinomatous. In one instance of cancer of the pylorus which I observed, perforation into the gall-bladder had occurred and the communication was shown by the barium meal (Fig. 378).

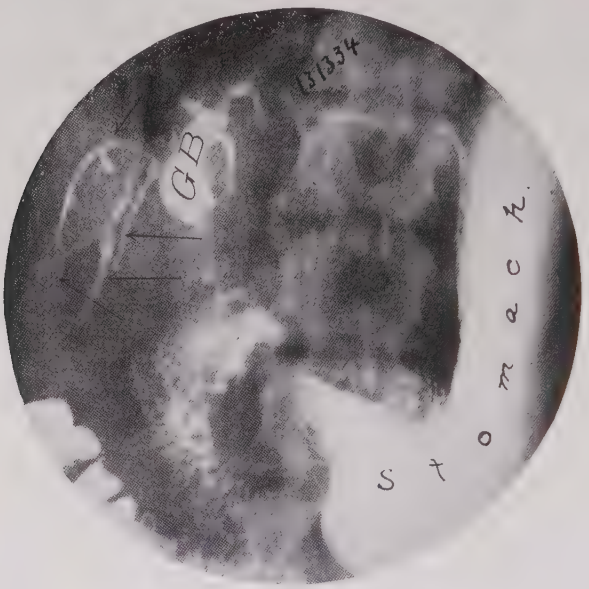

FIG. 378.—Carcinoma pyloric end of stomach; communication between duodenum and gall-bladder. Barium in gall-bladder, G. B. Arrows point to barium in hepatic ducts.

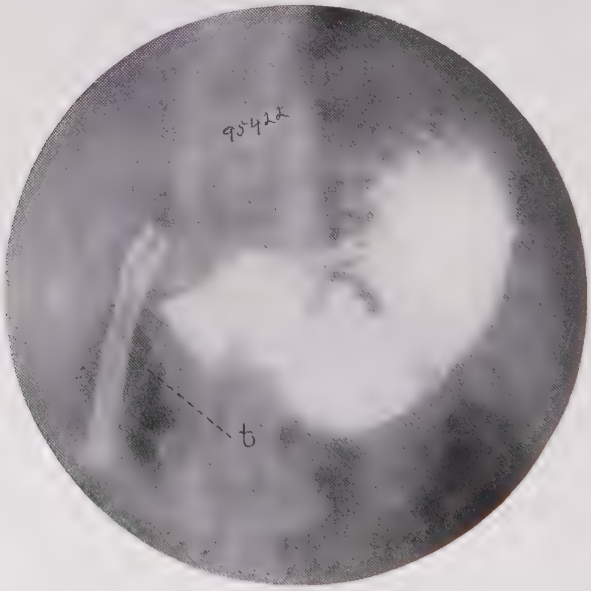

FIG. 379.—Reconstruction of common duct (Sullivan method). Rubber tube, *t*, partly in common duct, partly in duodenum.

Overactive gastric peristalsis, with an increase in the number of waves, is not infrequently seen, with or without duodenal or pyloric obstruction by adhesions. Though more numerous, the waves are not deepened as a rule, and are usually more marked on the greater curvature than on the lesser.

Case[9] considers the presence of a Riedel's lobe of the liver, which may be demonstrable after inflation of the colon, as a valuable sign of cholecystitis.

The localization of a pressure-tender point, outside the duodenal shadow, is of questionable worth, though occasionally mentioned.

The most common lesions giving rise to symptoms which are often confusingly similar are gastric ulcer, duodenal ulcer, cholecystitis and appendicitis. When the roentgen findings are negative for the presence of a peptic ulcer, the field of reasonable consideration is narrowed to the gall-bladder and appendix. Certainly, negative roentgen findings do not exclude the possibility of peptic ulcer, but they do exclude its probability, and the diagnostician usually welcomes this aid.

THE LIVER

Although a roentgenologic examination of the liver is not often requested by clinicians, definite and useful information may sometimes be elicited by this means. The upper border of the hepatic shadow, coinciding with the diaphragm, may be readily made out. Its lower border ordinarily shades off somewhat indistinctly, but by inflating the stomach and colon it may be shown more or less plainly. Thus, it is possible to determine certain abnormalities of size, form and position.

An increase of the liver-volume, with general and symmetrical enlargement of its shadow, may be due either to hyperemia, or to an actual hypertrophy resulting from various causes, including amyloid degeneration, cancer and syphilis. The diminished shadow of an atrophic liver may be distinguished when the commonly accompanying ascites has been relieved by paracentesis.

Local deformities of the hepatic contour are sometimes

visible as a result of cancer, syphilis, abscess, or cyst. In cancer, nodulation along the diaphragmatic border is occasionally marked. Subdiaphragmatic abscess may be manifested by elevation and fixation of the diaphragm, with clear lung area above and normal costo-phrenic angle (Fig. 380). In some cases there may be a visible collection of gas and fluid below the diaphragm. The liver, being plastic, may sometimes mold itself into the distortions of the diaphragm occasionally pro-

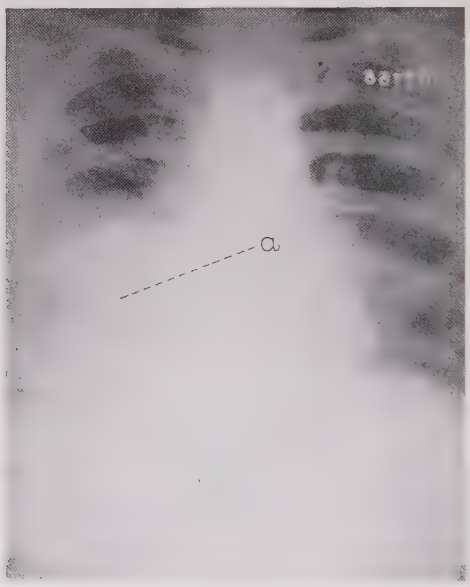

FIG. 380.—Subdiaphragmatic abscess. Abscess area, *a*; diaphragm high and fixed.

duced by pleural adhesions. Jaugeas[10] reports two cases in which hydatid cysts, peripherally situated, gave rise to smoothly contoured shadows resembling those of abscesses. Since it possesses a degree of mobility, the liver is subject to displacement both by physiologic and pathologic causes. Distention of the stomach and intestine with food or gas may displace the liver upward, or laterally to some extent. Ascites and large intra-abdominal tumors also may elevate the liver, or it may be depressed by intrathoracic conditions—emphysema, pleural effusion, etc. Transposition of the liver occurs, of course, in

the rare cases of *situs inversus*. Normally in contact with the diaphragm, the liver may be ptosed, in which case the separation of the upper hepatic border from the diaphragm becomes apparent (Fig. 381). In marked hepatoptosis the transverse colon has been seen between the liver and the diaphragm. The normal rise and fall of the liver with expiration and inspira-

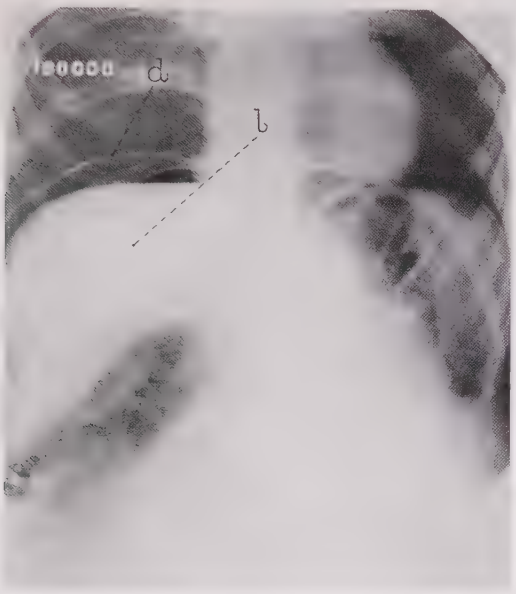

FIG. 381.—Slight ptosis of liver, *l*. Diaphragm, *d*. The right lobe of the liver is well outlined because of the clear lung area above and the gas in the colon below.

tion is sometimes evidently diminished or absent when fixation has resulted from inflammatory processes, either in the chest or upper abdomen.

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CHAPTER XIX

THE SMALL INTESTINE

In most instances the small intestine may be studied as a supplement to and during the examination of the stomach. Thus its disposal of the six-hour meal, some of which will usually remain in the lower ileum, may be observed, while the duodenum and upper jejunum will ordinarily be visualized soon after ingestion of the barium water (aqueous mixture). Visualization can often be assisted by manual expression of the gastric contents. Occasionally, but not often, there is some advantage in tracing the progress of a single meal through the intestine by examination at frequent intervals. The standing position is commonly employed for screening, but the recumbent position may be of service in investigating the lower coils of the ileum which often lie behind the pubic arch when the patient is standing and are thus difficult to manipulate. With the patient in the right lateral decubitus or in the prone position the duodenum is occasionally more completely filled and its condition can be more accurately determined.

THE NORMAL SMALL INTESTINE

The Duodenum.—Beginning at the pyloric hiatus, sweeping upward or outward, then to the right and downward, around the head of the pancreas, the duodenum presents roentgenologic appearances which may vary considerably within normal bounds. Somewhat resembling a horseshoe in its course, the duodenum is divided by some anatomists into three portions, by others into four.

The first segment, or pars superior, includes the bulb (cap) which is the most expanded portion of the duodenum and is of especial interest. When filled with barium it is seen in the

anterior view as a smoothly contoured, more or less conical or beehive-shaped, chamber, with its base at the pyloric ring (Figs. 382 and 383). The direction of its long axis depends

FIG. 382.—Normal duodenal bulb, *b*.

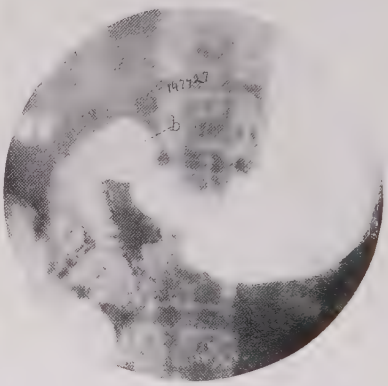

FIG. 383.—Normal duodenal bulb, *b*.

FIG. 384.—Entire duodenum well visualized.

FIG. 385.—Serrated outline of upper jejunum, *j*.

largely upon the form of the stomach, whether steer-horn or fish-hook. With a pronounced steer-horn type of stomach the long axis of the bulb is often quite horizontal. With the fish-

hook type of stomach the bulb is usually seated vertically over the pylorus. Between these types various angles of obliquity upward and to the right are often seen. A fish-hook stomach lying well to the right may also carry the base of the bulb with it and thus incline the long axis of the bulb upward and to the left.

The conical peak of the bulb as usually seen in the anterior view suggests a marked narrowing of the duodenum at that point, but this narrowing is only apparent and is due to the course of the duodenum which turns backward from the bulb, then outward and downward. The fact that the duodenum is not narrowed can be shown by an oblique or lateral view.

The shadow of the barium-filled bulb under normal conditions is more dense than the remainder of the duodenal shadow, due in part to the more anterior situation of the former, its greater size and the tendency of the opaque meal to tarry here momentarily. Its form is fairly symmetrical, and its contour is smooth, as it contains no valvulæ conniventes. Its size varies markedly; a bulb 2×4 cm. and one three or four times as large may each be normal. The proportion of length to breadth also varies; with an elongated, low-lying stomach the bulb may have the length and breadth of a finger; ordinarily the disproportion is not so great. Commonly, the base of the bulb shows as a straight line, but if the bulb is large the base may curve slightly downward peripherally.

By reason of the rapid transit of its contents, the second or descending (vertical) portion of the duodenum is not often well visualized. As seen from in front it may descend quite vertically or curving with a right convexity, and thus its apparent angle with the superior portion varies in acuteness. With a stomach displaced to the right, the descending portion of the duodenum may be hidden behind the bulb and antrum. When seen, its shadow is far less dense and homogeneous than that of the bulb, and the barium passing through it in small quantities makes it appear narrower than it is.

The third (transverse) portion of the duodenum extends more or less horizontally from the vertical portion toward the spine, then curves upward, the latter segment being sometimes described as a fourth portion. The suspensory ligament of Treitz marks its termination and the beginning of the jejunum, the juncture being sometimes visible as a flexure at that point. The valvulæ conniventes, rudimentary in the lower half of the first portion and in the second portion, are well marked in the third portion, so that the shadowed barium in the latter shows a serrated appearance. The aspect of the normal duodenum is shown in Fig. 384. As to mobility, the bulb can be shifted about to some extent by palpatory manoeuvers, but the remainder of the duodenum is fixed and not responsive to manipulation.

Peristaltic movements in the duodenum are difficult to detect. Under ordinary circumstances the bulb is seen to fill, then suddenly to overflow into the descending and transverse portions, through which the barium races quickly, and the entire duodenum is more or less completely evacuated, seemingly as though by siphonage, rather than by an active expulsive contraction of the duodenum itself. However, competent observers have noted actual peristalsis, rhythmical in character, at minute-long intervals.

The Jejunum.—Beginning at the duodenojejunal juncture, the first segment of the jejunum courses either directly toward the left hypochondrium or downward and to the left. The first loops are often seen soon after ingestion of the barium-water, especially if the exit through the pylorus is free. Issuing from the duodenum, a barium-mass is sometimes observed to dart suddenly across the abdomen to the left, where it is speedily broken up and diffused through that portion of the intestine, making its subsequent course untraceable. The barium-shadowed jejunum shows as an indefinite grayish cloud, with here and there the feathery effect of the valvulæ conniventes (Fig. 385).

The movements of the small intestine have been studied in

animals by Cannon, and in man by Hurst, Béclère and others. In cats Cannon[1] has observed what he calls "rhythmic segmentation," and two varieties of peristaltic movement. Rhythmic segmentation consists in a sudden division of a long food-mass into many little segments of nearly equal size; then these segments are again suddenly divided, and the neighboring halves unite to make new segments, and so on. From the beginning to the end of the period of segmentation, the food changes its position in the intestine to only a slight extent. The rapidity of the changes is remarkable, the rate of division being twenty-eight or thirty times in a minute. The peristaltic wave is seen in two forms. The first merely transports nutriment from one region to another near by. Its rate is slow, being variously estimated as 1 or 2 cm. per minute. The wave-contraction involves 4 or 5 cm. of the intestine, whereas the rhythmic segmenting contraction is hardly more than 1 cm. broad. The second form of peristaltic wave, the peristaltic rush, is swift, and may glide rapidly from one end of the canal to the other. Cannon mentions also the so-called "pendulum movements" which have been variously described by different observers, and which he characterizes as a gentle swaying movement of the coils accompanying the rhythmic contractions.

In man, Hurst[2] has on numerous occasions observed well-marked segmentation, at the rate of ten divisions in a minute and a half. The shadow of the cecum began to appear, on an average, at four and three-eighths hours; hence, he computed the rate at which the intestinal contents travel as about 2.5 cm. per minute.

Faulhaber[3] refers to the roentgen-kinematographic studies of Kaestle and Brugel as showing a mixing and kneading movement (segmentation) and a propulsive peristaltic movement.

Béclère and Mériel,[4] as well as others, state that after a half hour the opaque meal is seen in the left and mid-abdomen. After two hours it predominates in the middle and lower abdomen. After four hours it occupies only a portion of the ileum and is

already manifest in the cecum. At six hours only a little remains in the terminal ileum. At eight hours the small bowel is completely empty.

The Ileum.—In the ileum the valvulæ conniventes gradually disappear distally until the lower segments become quite smooth. These latter lie in the lower mid-abdomen and right iliac fossa, usually contain a good portion of the meal given six hours previously, and thus may be studied during the routine examination of the stomach (Fig. 386). By manipulation and pressure, the coils, which are often massed together, may be

Fig. 386.—Terminal ileum, *i*, as seen six hours after giving the meal.

separated for scrutiny, except in enteroptotics who are likely to have the lower ileum well down behind the pubic arch. Here the recumbent position may make palpation effective. The terminal segment, which is often involved in pathologic processes, deserves especial attention. In entering the ileocolic juncture it lies at varying angles from the cecum. Frequently it rises alongside the cecum and turns abruptly into the cecal notch; in other instances, the last 8 to 10 cm. lie at a right angle to the long axis of the ascending colon, and exceptionally the terminal segment descends to its juncture with the large bowel.

Normally, as seen on the screen, the barium-filled lower coils

of the ileum appear to have the breadth of a finger, with an unbroken contour, and are mobile in proportion to their situation and the relaxation of the abdominal wall. Peristaltic movement, with waves of slight depth succeeding each other rapidly, has been observed, but this is seldom seen during an ordinary examination.

Motility of the Small Bowel.—An important factor in the motility of the small intestine is the rate of gastric evacuation. Other elements which influence it are the character and quantity of the opaque meal, and whether or not the patient has been subjected to purgation and fasting, or other unusual conditions. With the routine method previously described for examination of the stomach, and with normal or average gastric motility, the "head" of the six-hour barium meal will most often be in the ascending colon while a good portion will still be in the terminal loops of the ileum. The remainder of the small intestine will, as a rule, be empty, although there may at times be a few scattered remnants in the upper ileum.

The normal limit for fairly complete evacuation of the small bowel, as defined by roentgenologists who have occupied themselves with the matter, ranges from eight to fifteen hours after taking the meal. These figures are generally based upon a meal of barium or bismuth in fluid carbohydrate mixtures, given without previous purgation or subsequent fasting. Further, the gastric evacuation-time should be taken into account in drawing conclusions.

THE ABNORMAL SMALL INTESTINE

The Duodenum.—Irregularities of the duodenal contour have as their more common causes, spasm or scar-contraction from duodenal ulcer and pericholecystic adhesions. Such irregularities are more often manifested in the bulb, and are there more easily discovered (Fig. 387). The inner contour of the bulb is sometimes indented by pressure against the spine. An accessory pocket, resulting from perforated ulcer, may show as a somewhat spherical adjunct to the duodenal lumen, with

successive layers of barium, fluid and gas, like the accessory pocket of perforated gastric ulcer, but a localized retention within the duodenum itself or adjacent small bowel may exhibit similar phenomena. Duodenal diverticula show as a pouch-like adjunct.

Among the important roentgenologic findings in the duodenum are the evidences of obstruction, the usual cause of which is either a stenosing duodenal ulcer or the adhesion bands of a pericholecystitis. These evidences include localized and permanent narrowing of the lumen, with dilatation proximal

Fig. 387.—Irregular bulb, *b*, in a case of duodenal ulcer.

to it, and delayed motility. Local constriction may give the duodenum an hour-glass form. As mentioned before, in the upright sagittal view the vertical portion of the duodenum often appears to be narrowed, and the bulb seems to have a conical termination; neither of these appearances should be mistaken for stenosis. The apparent size of the bulb, as well as that of the entire duodenum, depends largely upon the balance between the volume of inflow through the pylorus and the rate of duodenal evacuation, so that what seems to be a narrow duodenum, as seen with the patient standing, may in fact be of normal caliber and appear thus when the patient is placed in the right lateral or prone position.

Dilatation proximal to the point of stenosis is a natural

sequence of obstruction. Dilatation of the bulb should be judged with caution, since its size varies widely within normal limits, but extreme degrees of expansion are to be regarded with doubt.

A more dependable sign of obstruction is delayed motility. While the normal duodenum will, as a rule, evacuate its contents practically as fast as they are received, usually within a minute, the barium will occasionally lag slightly in its transit, especially through the third portion, and this is not necessarily significant. But with organic obstruction there is sometimes an evident delay at the point of stenosis, and a manifest and persistent accumulation of the barium proximal thereto. In extreme stenosis a residue from the six-hour meal may be found in the duodenum. Six-hour retention in the stomach or gastric hyperperistalsis may also suggest duodenal obstruction, a combination of residue and hyperperistalsis being strongly indicative of ulcer with obstruction.

The observation of hyperperistalsis of the duodenum itself above an obstruction has been recorded. This activity has, in some instances, been described as extremely marked and of a "writhing" character. Even duodenal antiperistalsis has been noted rarely.

Kinking at the duodenojejunal juncture as a feature of intestinal stasis has been given considerable attention by a few roentgenologists. Acuteness of the duodenojejunal angle (kinking) with dilatation and hypomotility of the duodenum are regarded by them as important evidences of stasis.

Lessened mobility or fixation of the duodenal bulb may be the result of an inflammatory process in that region, but immobility may be only apparent and due to rigidity of the abdomen.

The Abnormal Jejunum.—Practically the sole abnormality of the jejunum (and upper ileum) showing definite roentgenologic signs is obstruction. When the obstruction is pronounced, these signs are quite decisive; the immense dilatation of the small bowel, delicately ribbed by the valvulæ conniventes, the delayed emptying, accumulations of barium at different points

with fluid and gas above them, and the tendency of the dilated loops to arrange themselves vertically, are characteristic. Obstruction high up in the jejunum may result in a six-hour gastric residue. New growths (more commonly carcinomas) and adhesions from inflammatory processes are the usual causes of stenosis. Unless a tumor mass can be palpated, the nature of the obstructing lesion can hardly be predicted, nor can its exact seat usually be determined. Multiple obstructions of slight degree, as evinced by numerous collections of barium from the six-hour meal scattered irregularly through the small bowel, have been observed in tuberculous enteritis and peritonitis. Not uncommonly, however, a few small detached masses of barium will lag far behind the bulk of the meal in a normal intestine, and these should not be hastily seized upon as proof of obstruction.

The Abnormal Ileum.—Since the terminal portion of the ileum can be well visualized, as a rule, it is perfectly feasible by the roentgen examination to detect abnormal variations of its position, mobility, size, contour, and motility.

The most frequently noted displacement of the lower ileum is "ptosis," being rather constant in persons of the enteroptotic habitus, and these constitute a large percentage of all cases examined. The significance of such "ptosis" is variously regarded, but when it is in harmony with the general make-up of the individual, its importance should not be exaggerated. Often several loops are situated deep in the true pelvis, and from here the terminal segment makes a steep ascent to the ileocolic juncture. Displacement in any direction may be the result of pelvic tumors. With failure of the first part of the colon to orient itself (incomplete torsion), the ileocolic juncture may lie on the outer aspect of the large bowel. In the rare cases of non-rotation of the colon and situs inversus the ileum or its terminal portion will be correspondingly situated.

Dilatation, consequent upon obstruction, may be demonstrable. Proximal to a severe stenosis the dilatation may be extraordinary, and the ileum may be distended to the size of

the colon. Definite narrowing of the ileal lumen is sometimes seen in the last few inches of its course, resulting, as a rule, from adhesion-producing pericecal inflammation. Very often, however, the contents of this part of the ileum are seen strung out irregularly when no organic constriction is present.

The mobility of the ileum should be in correspondence with its accessibility to palpation and the degree of abdominal relaxation. Fixation by adhesions from pathologic processes, which originate for the most part in the appendix or cecum, may be shown by immobility of the affected segment upon manipulation and change of the patient's position. Such adhesions may also produce localized irregularities in the contour of the gut.

The term kink, which would imply a sharp angulation of the bowel, is very often applied to localized narrowing with fixation, whether or not angulation is present. What seem to be acute flexions of the bowel are frequently due merely to the plane in which the loops are viewed.

The bulk of the six-hour barium meal heretofore described will, under average and normal conditions of gastro-intestinal motility, be evacuated from the ileum within six to eight hours. Any considerable delay of clearance beyond this time demands investigation. If the gastric and upper intestinal clearance has been normal, a prolonged delay in the lower ileum is indicative of obstruction. Stenosis of high grade may result in ileal retention for many hours or even days. The seat of obstruction is likely to be near the cecum and the more common causes are appendiceal inflammation, cancer, and ileocecal tuberculosis. Congenital stenosis at the ileocecal valve, though rare, is a possibility. In addition to marked retention or delay there will nearly always be other signs of organic obstruction, such as demonstrable local narrowing, fixation at the site of stenosis, and dilatation of the proximal gut. Between the cases which are clearly normal and those with definite signs of obstruction other than prolonged delay, there are cases in which the progress of the meal is somewhat retarded, but proof of any mechanical

obstacle is lacking. Some of the exponents of stasis consider such cases as belonging to this class.

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CHAPTER XX

DUODENAL ULCER

Though the condition of duodenal ulcer has been known for a century, it is only since 1900, when Weir[1] analyzed the cases reported in the literature and gave his own experiences, that duodenal ulcer became firmly grounded as an anatomo-pathologic entity of great practical moment. The frequency of the disease is shown by the fact that more than 4000 cases have been proved by operation in the Mayo Clinic and a great number have been diagnosed but not operated on.

In the past, ulcer of the duodenum has no doubt been confounded with ulcer at the pyloric end of the stomach, partly because of the assumption that any ulcer found in the vicinity of the pylorus must necessarily be gastric, and partly because of the difficulty of determining the exact site of the pylorus. In 1907, W. J. Mayo[2] called attention to the pyloric veins as a landmark corresponding accurately to the pyloric sphincter. More careful determination of the pyloric site has resulted in finding that the ratio of frequency between duodenal and gastric ulcer is far greater than had been supposed, being now stated as three, and even four, to one.

Symptoms.—The symptom-complex in a typical case of duodenal ulcer is emphatic and convincing. The "hunger-pain," a burning or gnawing epigastric distress, coming two hours or more after meals and late at night, and quickly relieved by food or drink; the exaggeration of the subsequent distress by acid and fibrous foods, such as fruits and coarse vegetables; the periodicity of the attacks, lasting for weeks, with intermissions of weeks or months; the hyperacidity, sour eructations, and occasionally also hematemesis or tarry stools, all combine to form a significant clinical picture. So nearly

characteristic is this syndrome that it has easily taken first rank in the diagnosis. Nevertheless, it is not infallible, for similar clinical histories are sometimes elicited in cases of gastric ulcer, gastric cancer, cholecystitis and appendicitis. Furthermore, many patients, more especially neurotic ones, from frequent examinations and interrogations may learn the typical ulcer history; in these cases the surest means of differentiation is by a careful x-ray examination. Moreover, the history in duodenal ulcer is frequently atypical and indecisive. Errors, both of omission and commission, are an inevitable consequence of all subjective diagnoses, and the effort is constant to supplement or supplant subjective methods by more exact objective methods. In duodenal ulcer the x-ray usually provides the desired objective data. Even when the roentgen examination does not speak independently and with certitude, it aids in excluding or confirming the simulants of duodenal ulcer, and thus furnishes adjunctive information to the clinician which may establish a decision. Efficiency in the roentgenologic diagnosis of duodenal ulcer has been developed only in recent years, some time after the x-ray had become an accepted aid in the diagnosis of gastric ulcer and other lesions of the digestive tract. The anatomical differences between the stomach and duodenum, the thinness of the duodenal wall, the lack of a sphincter to prevent rapid egress of the opaque meal from the duodenum, all seemed to be insuperable obstacles to obtaining direct signs similar to those of gastric ulcer. Thus, for some time the only signs generally recognized were the secondary manifestations in the stomach, and, in the main, diagnosis by the roentgen-ray was less accurate than by the anamnesis. A more extended experience has shown, however, that besides the gastric findings, which are often sufficiently diagnostic, it is possible in most instances to obtain more direct signs of the duodenal lesion. At present, while the roentgen diagnosis is not errorless, its efficiency is fairly proportionate to the thoroughness of the examination, and by its objective nature is more persuasive than the clinical diagnosis.

Pathology.—To roentgenologists the pathologic anatomy of duodenal ulcer is of more than passing interest, since the location and character of the ulcer directly affect its roentgenologic demonstrability. Of prime importance is the fact that more than nine-tenths of these ulcers occur in the first 4 or 5 cm. of the duodenum, and usually on the anterior wall (Fig. 388). Less than a tenth of them are more distally situated, and these may be found in any part of the duodenum, even

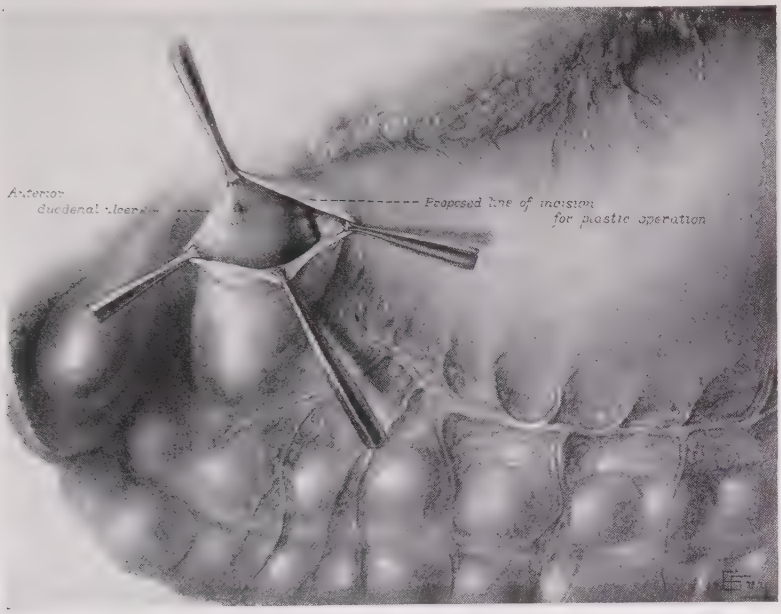

FIG. 388.—Drawing showing small ulcer in the anterior wall of the duodenum.

its third or fourth portion. Commonly single, the ulcer may have a companion, a "kissing" or contact ulcer, on the opposite wall, or several ulcers variously grouped and in various stages of evolution, may be present. Judd has excised many ulcers of the duodenum recently, and he has been impressed with their multiplicity. Macroscopically, the appearance of an ulcer depends upon its age and the resulting amount of scar-tissue (Fig. 389). A recent ulcer may be so small and shallow (Fig. 390) that no marked evidence of it can be seen on the outer coat of the bowel; its presence is determined by the

surgeon by palpation of the slightly thickened ulcer-area, which may also be hyperemic, or may show petechiæ (stippling) after rubbing with the finger or with gauze. With the majority of ulcers, however, external scarring is visible, but this may occur without marked contraction or deformity. The more chronic callous ulcers with extensive cicatricial contraction cause deformity and often stenosis. While an old ulcer may show a

Fig. 389.—Photograph of excised ulcer. Crater at *c*.

Fig. 390.—Photograph of excised ulcer. Crater at *c*.

deep crater of appreciable depth, it is notable that the excavation is often superficial. Regarding this, W. J. Mayo[3] says: "The mucosa of the duodenum is thin, smooth and granular, and chronic duodenal ulcers may not therefore have the characteristics we have learned to expect from experience with gastric ulcers. I have excised a number of duodenal ulcers in which there was considerable scar-tissue in the submucosa and muscularis and marked evidence of localized peritonitis; yet

the actual ulcer was a mere slit or dimple surrounded by an eroded, discolored patch of mucosa. This is the type of ulcer which occurs on the anterior wall unless there is a corn-like thickening over the top of the ulcer, in which case it will have the size, depth and callus characteristic of gastric ulcer."

A high percentage of ulcers penetrate to the serosa or perforate the duodenal wall. The perforation may be sealed by the adhesion of adjacent tissues, or the ulcerative process may invade the pancreas or liver and produce an accessory pocket (pseudo-diverticulum), similar to that of perforated gastric ulcer. An actual diverticulum, or at least a distinct pouching of the gut, is sometimes seen proximal to a stenosing ulcer. While no adhesions are found in the majority of cases of duodenal ulcer, they are a natural consequence of perforation, occur sometimes with the chronic non-perforated type, and are seen exceptionally in association with very small ulcers. Malignancy developing upon a strictly duodenal ulcer is exceedingly rare, although a gastric cancer has occasionally been known to develop on a duodenal ulcer which had extended to the gastric side of the pyloric ring.

Technic.—The technic of the roentgenologic examination for duodenal ulcer is practically inseparable from that of the gastric examination, for the secondary signs of duodenal ulcer are manifested chiefly in the stomach. Hence, the six-hour meal and the barium-water, with roentgenoscopy and roentgenography are all either necessary or advantageous. In addition to the gastric examination, the principal aim is to visualize the duodenal contour adequately and satisfactorily. Usually this can be attained during the routine vertical screen-examination. By manipulating the stomach, the barium-water can almost invariably be forced through the pylorus in quantity sufficient to fill the duodenal bulb. To obtain a clear view of the latter, it is often necessary to rotate the patient slightly to the right or to the left so as to bring the shadow of the bulb away from that of the spine. Exceptionally, when the stomach is of the acute fish-hook type and the bulb lies very near the lesser

curvature, rotating the patient a little to the left may show it more clearly. Examination of the patient recumbent on the screen-table has an advantage occasionally over the upright position by securing better filling of the duodenum. More important than the position is securing relaxation of the pyloric

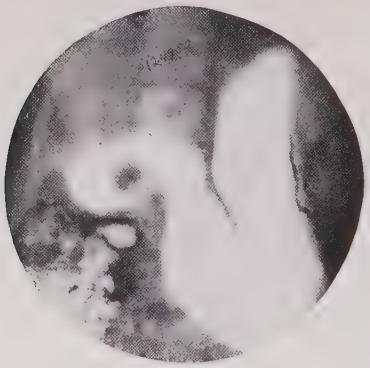

Fig. 391.

Fig. 392.

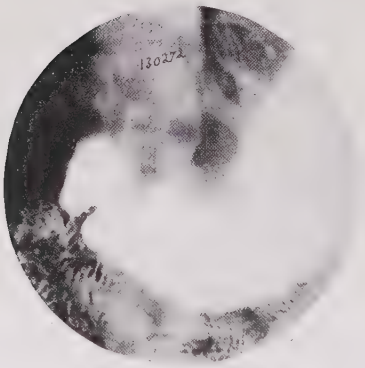

Fig. 393.

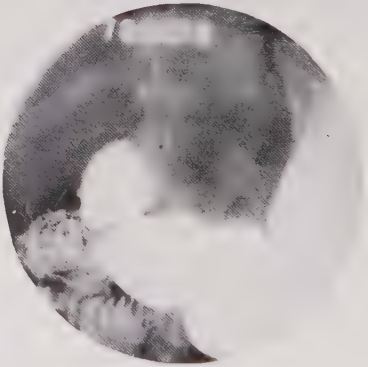

Fig. 394.

Figs. 391, 392, 393, 394.—Normal stomachs and duodenal bulbs.

sphincter. Adding a dram of sodium bicarbonate to the barium-water has seemed to promote this relaxation, and it is also furthered by the patient breathing deeply and relaxing all his voluntary muscles. Ordinarily, a good view of the cap will be obtained within a very few minutes, but in some instances the bulb may fill more completely after the patient has rested for a time and physiologic gastric evacuation has become more

pronounced. Waiting is sometimes also necessary to elicit the exaggerated peristalsis which is a common accompaniment of duodenal ulcer. Blocking the distal duodenum by manual pressure, or with Holzknecht's distinctor, sometimes favors duodenal distention and hence a better delineation of its contour.

In a large percentage of cases, if the examiner is experienced, the screen-examination alone will be fairly decisive as to the presence or absence of duodenal ulcer. Either a definitely deformed or a definitely normal bulbar contour will be seen, or the secondary gastric signs will affirm the diagnosis. In all doubtful cases reëxamination and plating are requisite. In making plates the recumbent position is most convenient, with the patient lying on his abdomen and rotated a trifle toward either side or in whatever angle at which the bulb was seen most clearly on the screen. Special tables are obtainable by which the image can be seen fluoroscopically and plates made at any desired angle of projection. Plates can be made at intervals, developing and examining each plate as made; when any plate shows a normal bulb, or an identical deformity appears upon each of several plates, the examination may be discontinued. Or, if preferred, a series of plates may be made successively and studied together. In either method it is imperative that the number of plates be sufficient to support a positive opinion. If economy is desired, devices can be had by which four or more exposures may be made on different parts of the same plate.

Roentgen Signs.—The roentgenologic indications of duodenal ulcer may be classified as follows:

A. Direct signs.
   1. Deformity of the duodenal contour.

B. Indirect signs.
   1. Alterations of gastric tone.
   2. Alterations of gastric peristalsis.
   3. Alterations of gastric motility.
   4. Gastrospasm.
   5. Tenderness localized to the duodenum.

Direct Signs.—1. *Deformity of the duodenal contour,* more specifically of its first portion, the bulbus duodeni, or cap, was first established as a practicable sign of duodenal ulcer by Lewis Gregory Cole[4] of New York, who developed the plan of "serial roentgenography," which in essence consists in making numerous roentgenograms successively and studying them in sequence. On theoretical grounds, the method did not seem to be either convenient or wholly trustworthy, and was regarded skeptically by many roentgen workers, including myself. The difficulty of obtaining a completely filled cap, the often insignificant anatomic changes produced by the ulcer, and the fact that bulbar distortion might be due to causes other than ulcer were urged as objections. However, more careful investigation has proved that bulbar deformity is feasible of demonstration and stands first among the roentgenologic signs in diagnostic value. The assumption that the distortion of the cap represented the organic alteration produced by the ulcer has contributed strongly to the doubt with which this sign was received, since it is known that many duodenal ulcers do not materially alter the duodenal topography. Yet ulcers of this kind often give rise to marked bulbar deformity in the roentgenogram quite out of proportion to the organic changes found at operation. The deformity of the bulb in these cases is, I am satisfied, solely or chiefly the result of intrinsic spasm exactly similar to the incisura of gastric ulcer or the spastic distortion of the pars pylorica so often seen associated with prepyloric ulcers. On this hypothesis it is possible to understand why the distortion of the bulbar shadow is more exaggerated than the deformity seen at operation. Absence of spasm would also explain why in some cases of ulcer no irregularity of the bulb-shadow is present (Fig. 398), a condition which I have observed in several cases and which proves beyond cavil that a well-rounded-out normal bulb does not exclude duodenal ulcer, and which also demonstrates that the spasm is not always constant (Figs. 395, 396, 397). The bulbar deformities more or less characteristic of duodenal ulcer may be divided into three general

classes: (1) Those due to organic distortion; (2) those due to organic changes plus spasm; (3) those which are produced by spasm only. In appearance the following types are noteworthy.

1. General distortion with sharply outlined projections and indentations, giving the bulb the semblance of a miniature

Fig. 395.

Fig. 396.

pine-tree or a bit of branched coral. This sort of bulb almost always means duodenal ulcer (Fig. 399). The distortion is largely due to spasm, this element being persistent and unvarying. In the classic cases of this type the entire contour of the

bulb is deformed; in others only one lateral border is distorted (Fig. 400).

2. Deformity of the basal border. Instances are not infre-

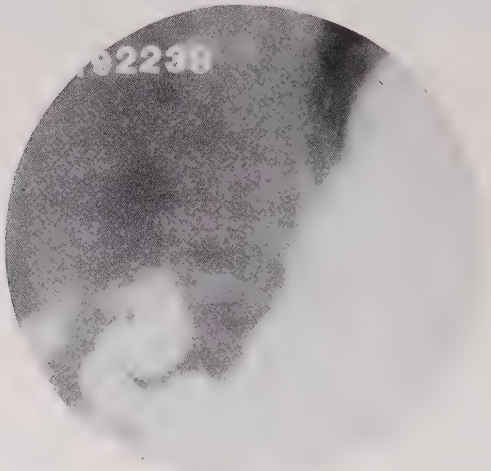

Fig. 397.

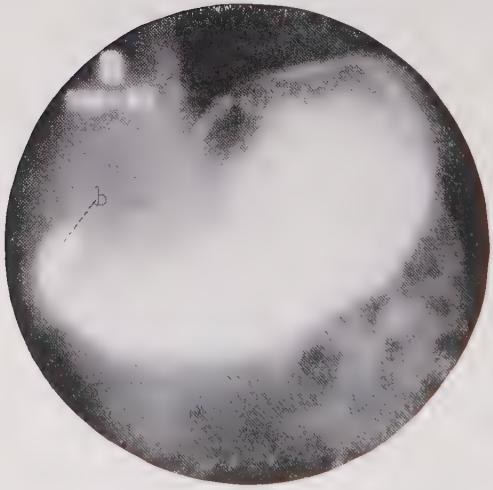

Fig. 398.—Apparently normal bulb, *b*. Duodenal ulcer found at operation.

quently encountered in which the base-line alone of the bulb is irregular. Most often the distortion is seen as a shaded filling-

defect, and, though definitely recognizable, may be quite small (Fig. 401).

3. The niche-type. The excavation of the ulcer is seen

FIG. 399.—General distortion of bulb, *b*.

FIG. 400.—Unilateral distortion of bub, *lb*.

as a barium-filled recess projecting from the bulbar chamber. It varies from a wheat grain to larger in size, and its barium content is often denser than that in the rest of the bulb (Fig.

402). The niche may or may not be accompanied by organic or spastic deformity elsewhere in the bulb.

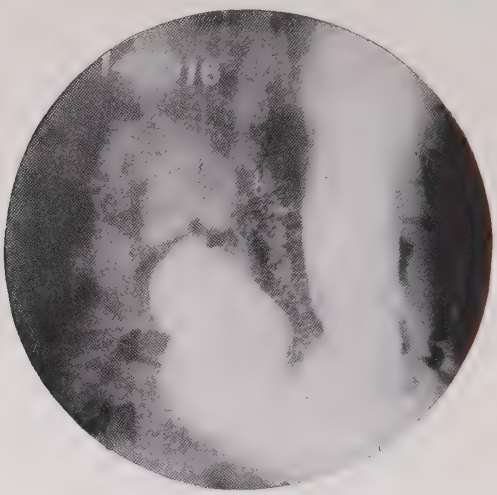

Fig. 401.—Deformity of basal border, *b*.

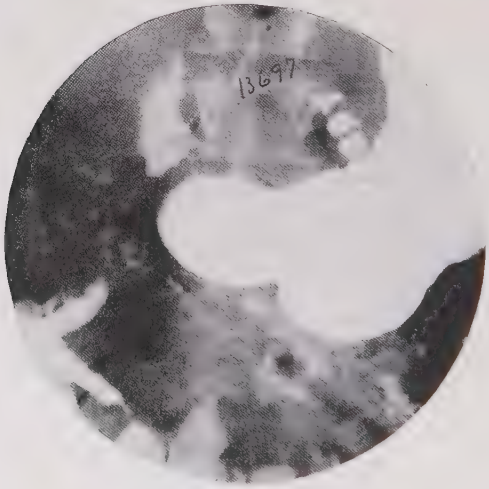

Fig. 402.—Niche-type of bulbar deformity. Niche at *n*.

4. The incisura-type of deformity. The incisura may be unilateral or bilateral (hour-glass). It is usually small but sharply outlined, is evidently spastic, presumably occurs in the plane

of the ulcer, and may be the sole abnormality of contour observed (Fig. 405).

FIG. 403.—Niche-type of bulbar deformity.

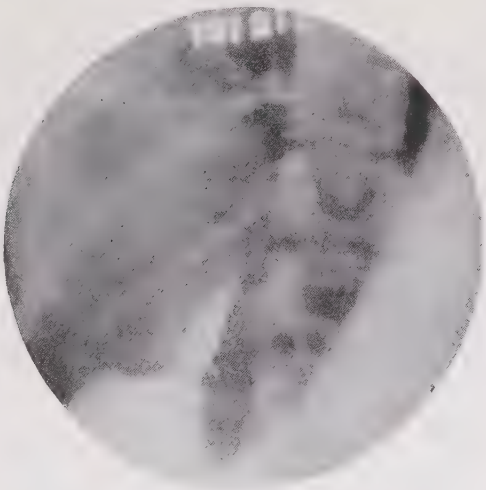

FIG. 404.—Niche-type of bulbar deformity.

5. In occasional instances the bulb is represented by a very small but compact mass of barium. There is no particular irregularity of contour, but the bulbar shadow is abnormally

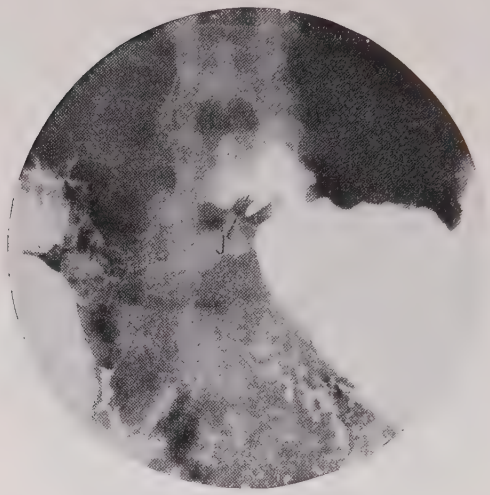

Fig. 405.—Incisura-type of bulbar deformity. Incisura at *i*.

Fig. 406.—Incisura-type of bulbar deformity.

small (Fig. 408). Sometimes this sort of bulb is produced by an ulcer stenosing the duodenum, so that only the proximal

FIG. 407. Incisura-type of bulbar deformity.

FIG. 408.—Diminutive Bulb, *b*.

portion of the bulb is filled. But, unless other signs of obstruction (gastric retention, antral dilatation, etc.) are also present,

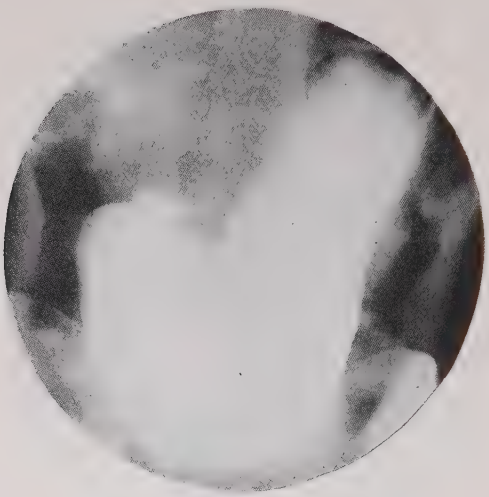

Fig. 409.—Diminutive bulb, perforated ulcer.

Fig. 410.—Accessory pocket, *b*, of perforated duodenal ulcer.

a diminutive cap should not be considered indicative of ulcer, since it may exist normally, or may be only partially filled and thus appear small.

6. The accessory pocket of a perforated ulcer which has invaded tissues outside the duodenum, shows as a projection from the bulbar contour (Fig. 410). It may be rounded or

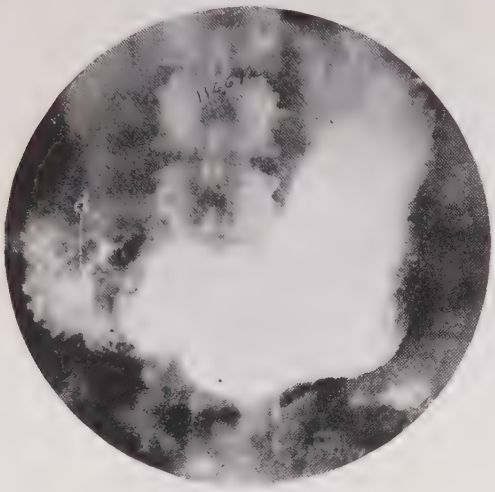

Fig. 411.—Diverticular sac at *d*, in a case of duodenal ulcer.

uneven in outline, and its contents may be arranged in layers of gas, fluid and barium. Often it contains a residue from the six-hour meal.

7. A diverticulum also appears as a sac-like addition to the bulb proximal to the site of the ulcer. As a consequence, the basal portion of the bulb is usually enlarged (Fig. 411). Since a diverticulum is sometimes associated with a stenosing ulcer, other indications of obstruction will generally be noted also.

The foregoing deformities have all been described as pertaining to the bulb, because ulcers are more commonly situated in this part of the duodenum. Ulcers located in other segments of the duodenum doubtless produce similar deformities, but they are more difficult to recognize by the x-ray. This is due to the irregularity of outline normally present and caused by the

valves of Kirkring. In ulcers distal to the bulb, if a roentgen diagnosis is made at all, it is made on indirect signs, such as a large stomach with six-hour retention, hyperperistalsis, etc.

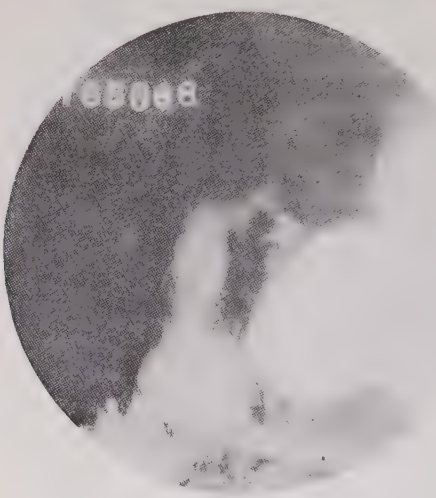

Fig. 412.—Bulb partly filled and resembling the deformed bulb of duodenal ulcer. See Fig. 413.

Fig. 413.—Filled bulb of normal contour. Same case as in Fig. 412.

Distortion of the bulb is not always easy to determine. With experience the observer soon becomes familiar with the gross and typical deformities which are pathognomonic of ulcer. Like-

wise, when the bulb fills completely and is of normal contour the fact is readily apparent. But to distinguish a deformed cap from one which is only partially filled is oftentimes very troublesome (Figs. 412 and 413). Cases without ulcer are frequently met with in which the bulb as seen on the screen and on plates, especially the latter, fails to show a normal contour, simply because of incomplete filling. This happens most often in cases in which the duodenum is very large. It is difficult in these cases to press enough barium from the stomach to fill the bulb and after it is filled to a certain point it begins to empty, and from this point the outflow from the duodenum is as rapid as the inflow from the stomach. It has occasionally happened that we could not diagnose ulcer roentgenologically in some of these cases. It is somewhat characteristic of these cases that the defective or unfilled area usually shifts its situation, as shown by careful comparison of the plates or superposing them, and, as a rule, if the examination is continued a filled bulb of normal contour will finally be obtained. A bulb of apparently normal and fairly regular outline is sometimes on closer inspection found to be eccentrically placed with respect to the pyloric canal, so that the major part of the bulb lies on one or the other side of the pyloric axis. In reality only a part of the bulb is seen, and the examination must be continued until a normal bulb with a symmetrical base or a positive and unvarying deformity is shown.

The significance of a deformity does not depend on its size but on its constancy. It is incumbent, therefore, on the examiner not only to make his observations with extreme care lest he overlook any relatively minute irregularities of contour, but he must also make certain of their persistence. *In an overwhelming preponderance of cases, a constant bulbar deformity means duodenal ulcer.* It is not absolutely diagnostic, since distortion of the duodenal shadow may also result from an inflammatory adhesion-producing process in the right upper abdominal quadrant, notably pericholecystitis, or from cancer of the duodenum, or possibly from purely reflex spasm set up

by conditions outside the duodenum. While bulbar deformity from adhesions about the gall-bladder does occur occasionally (Fig. 414), it is not a common cause of error, as I have seen cases in which the duodenum was matted in adhesions, yet the contour of its lumen was not deformed in the roentgenogram. Cancer of the duodenum is so rare that it should be thought of last of all.

Fig. 414.—Hour-glass deformity of duodenum due to delicate adhesions from a pericholecystitis.

As to the possibility of duodenal deformity by extrinsic spasm, it must be admitted that other portions of the alimentary tube are affected by reflex spasm originating from causes outside the digestive canal, and presumably the duodenum is not an exception, for I have seen some constant deformities of the duodenal bulb which at operation did not prove to be duodenal ulcer. In one case disease of the gall-bladder (Fig. 415), in another cholelithiasis (Fig. 416), and in another cancer of the pancreas were present (Fig. 417). Shifting and intermittence commonly characterize extrinsic spasm, and if the duodenum were thus affected, the observer would probably be unable to dis-

FIG. 415.

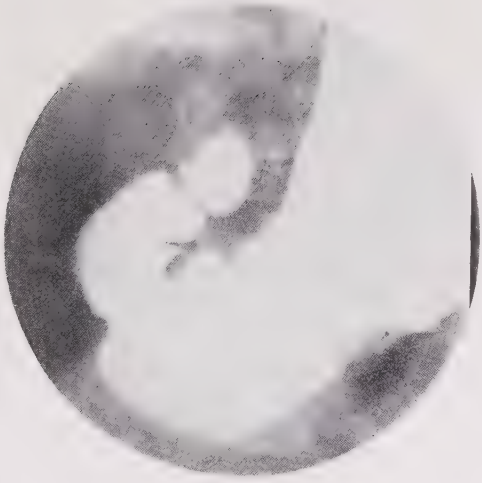

FIG. 416.

tinguish it from incomplete filling due to a scanty flow through the pylorus, or rapid duodenal evacuation, or both. Pressure against the spine may deform the bulbar outline, especially its

Fig. 417.

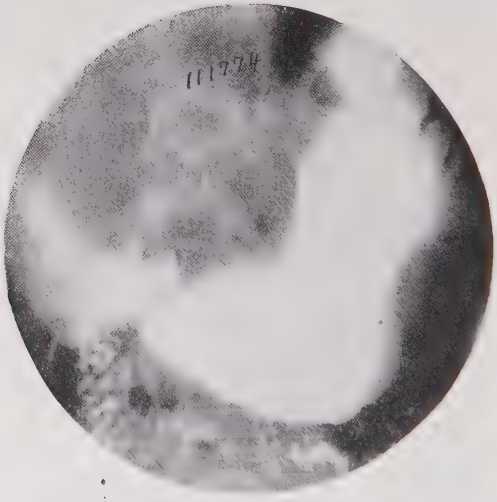

Fig. 418.—Distortion of bulb by pressure against the spine.

inner border, but by using both screen and plate the cause should be evident (Fig. 418). The smooth, concave indentation of the outer border of the cap, sometimes produced by the gall-

bladder, has no resemblance to the irregular deformity of ulcer. The fact has been mentioned that duodenal ulcer may exist without detectable distortion of the bulbar shadow. Such instances, however, are relatively uncommon, and the observer should consistently report them as roentgenologically negative.

Indirect Signs.—1. *Alteration of gastric tone.* The most common change of gastric tone, associated with duodenal ulcer, is to a hypertonus (Fig. 419). This, together with hyperperistalsis and hypermotility, constitutes a triad of "hypers"

Fig. 419.—Gastric hypertonus in a case of non-obstructive duodenal ulcer.

which was given early recognition as being rather strongly indicative of duodenal ulcer. The hypertonus may be explained upon either of two grounds: First, it may occur simply as a reflex from the irritated ulcer—a spastic increase of tone which stops short of the general reflex gastrospasm familiar as a sequence of numerous conditions outside the stomach. Second, it may result from the effort to overcome beginning stenosis of the duodenum, whether due to contraction of the ulcer-scar or duodenal spasm. A compensatory hypertonus of this sort preceding muscular hypertrophy would be a natural and first response to distal obstruction. Whatever the reason, hyper-

tonus is seen with the majority of duodenal ulcers, and perhaps more frequently in this than in any other condition. True, it occurs also as a normal feature of the steer-horn stomach seen now and then in persons of the broad habitus, and is an occasional accompaniment of various pathologic conditions other than duodenal ulcer. With markedly obstructing duodenal ulcer, if of long standing, there is a gradual failure of compensation and the

Fig. 420.—Marked gastric hypotonus; obstructive duodenal ulcer.

stomach becomes hypotonic. If of moderate degree the effect may be chiefly noticeable in the antrum, which is larger than normal, and the examiner soon begins to regard antral dilatation as more or less significant. In the extreme degrees of hypotonus the entire stomach as well as the antrum is expanded to immense size, the condition is obviously one of dilatation rather than functional atony, and the existence of obstruction is practically certain (Fig. 420).

2. *Alterations of Gastric Peristalsis.*—Hyperperistalsis is notable in a large proportion of cases, perhaps 60 per cent. or more.

It varies from a slight increase of wave-depth and frequency to a tempestuous energy of contraction. It is most exaggerated in the obstructive cases, but it occurs also when there is no obstruction. A characteristic feature is the regular succession and symmetrical correspondence of the waves on both curvatures which are equally indented (Fig. 421). Three or four pairs are seen in progress at once, whereas only one or two pairs

Fig. 421.—Hyperperistalsis; four waves running.

are seen normally. A mere exaggeration of wave-depth should not be confounded with hyperperistalsis, since an essential feature of the latter is an increase in the number of the waves, although they may also show unusual vigor. Hyperperistalsis is often intermittent in character, periods of activity alternating with periods of rest (Figs. 422 and 423). Its appearance is sometimes a little delayed after the stomach is filled, but not usually beyond five or ten minutes. Of course, the phenomenon of hyperperistalsis is not limited to duodenal ulcer. It may accompany lesions of the gall-bladder or appendix or

be seen normally in the hypertonic steer-horn stomach, but in any of these, as a rule, it is less pronounced than in duodenal ulcer. Exaggerated peristalsis may sometimes be elicited by

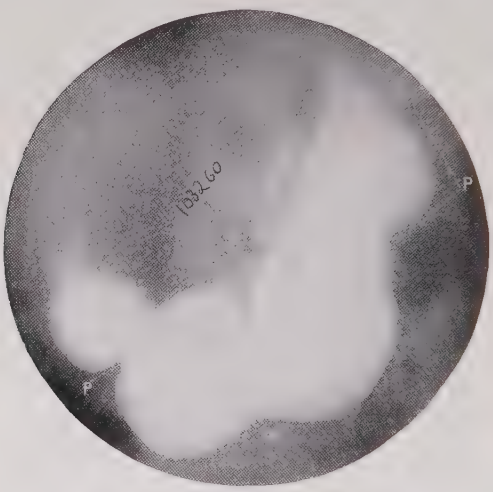

Fig. 422.—Hyperperistalsis. See Fig. 423.

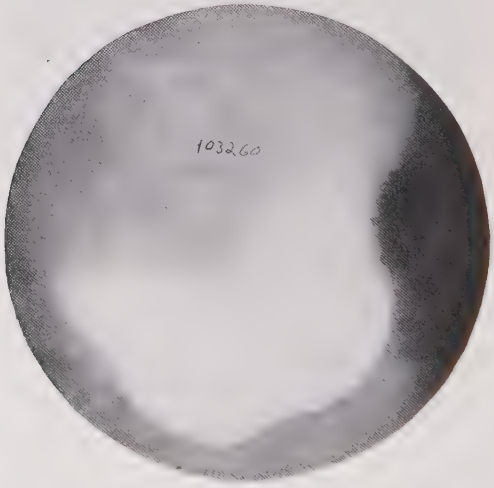

Fig. 423.—Same case as in Fig. 422. In this roentgenogram, taken within a minute after the one shown in Fig. 422, the stomach is practically at rest.

massage of the epigastrium in normal cases, or by palpating a tender appendix; it soon dies away when the stimulus ceases. The hyperperistalsis of duodenal ulcer requires no artificial ex-

FIG. 424.—Copious initial clearance in a case of duodenal ulcer.

FIG. 425.—Hypermotility. Advance of the six-hour meal well up to splenic flexure.

citation. Obstructing pyloric and pre-pyloric lesions are sometimes attended by hyperperistalsis, but this is nearly always of a disorderly character as to the depth and sequence of the waves, and these are seen chiefly on the greater curvature. Occasionally, however, this variety of peristaltic exaggeration accompanies perforated duodenal ulcer. In estimating the degree of peristaltic activity, it is to be remembered that peristalsis is more lively in the prone than in the standing posture, and that it is influenced by the character of the opaque meal. Comparisons should be made under identical circumstances.

The observation of antiperistalsis with duodenal ulcer has been reported. It was noted in a few cases with obstruction. In the main, antiperistalsis indicates pyloric or pre-pyloric rather than post-pyloric, lesions.

3. *Alteration of Gastric Motility.*—A logical result of hypertonus and hyperperistalsis is hypermotility, provided no marked obstruction has been produced by the ulcer. Rapid clearance of the stomach is also furthered by the patency of the pylorus so often observed. During screen-inspection the barium is seen passing out into the duodenum in a copious stream, not quite so voluminous as that seen with the gaping pylorus of cancer, but larger than normal (Fig. 424). Generally speaking, the spontaneous initial clearance in cases of duodenal ulcer is either of this profuse type, or, with marked obstruction, abnormally scant, and a moderate, intermittent outflow is not seen as under normal conditions. Hypermotility is also evidenced by the position of the six-hour meal, the "head" of which, instead of being in the cecum or ascending colon, as it is normally, may be in the transverse or even in the descending colon (Fig. 425). Again it must be recalled that hypermotility is not peculiar to duodenal ulcer and that it is of common occurrence in gastric cancer, achylia, and the diarrheas. If these are excluded, as can usually be done by considering the salient roentgenologic and clinical facts, a pronounced hypermotility hints strongly at the possibility of a non-obstructing duodenal ulcer being present.

FIG. 426.—Retention from the six-hour meal.

FIG. 427.—Marked hyperperistalsis; large stomach, otherwise normal; retention from the six-hour meal. The diagnosis of duodenal ulcer based on these signs alone was confirmed at operation.

FIG. 428.—Hour-glass stomach due to duodenal ulcer. Diagnosis, gastric ulcer. The bulb was not investigated as to deformity. At operation a duodenal ulcer was found, with stomach negative, and no hour-glass, the latter having been relaxed by the narcosis.

FIG. 429.—Gastric incisura in a case of duodenal ulcer.

On the other hand, more than one-fourth of the ulcers are sufficiently obstructive to produce a six-hour retention in the stomach (Fig. 426). A residue in a stomach with an unbroken contour, that is to say, without any roentgen evidence of gastric ulcer or cancer, should first of all suggest duodenal obstruction, the most common cause of which is duodenal ulcer. If, in addition to the gastric retention, there is typical gastric hyperperistalsis, the presence of a duodenal ulcer is practically certain (Fig. 427). In short, the combination of these two signs is quite as diagnostic as any other evidence that can be obtained, not excepting bulbar deformity.

4. *Gastrospasm.*—Duodenal ulcer is frequently associated with spastic manifestations in the stomach. The spasm is rarely or never of the total or regional type. Usually it takes the form of an incisura or an hour-glass contraction (Fig. 428). The incisura may be extraordinarily large and deep, in which case it usually travels toward the pylorus along with the deep peristaltic waves, of which it is perhaps an eccentric form. Again, the incisura is of slight or moderate depth, is seen anywhere along the greater curvature and is stationary (Fig. 429). Especially annoying is the fact that such an incisura may persist after belladonna has been given to the patient and thus arouse suspicion of a gastric ulcer. It is a vexing exception to the rule that spasm associated with conditions outside the stomach disappears after the administration of an antispasmodic. Other causes of gastrospasm have been discussed in the chapter on this subject.

5. *Tenderness* localized to the duodenum is included in many of the older lists of ulcer signs. In some cases the tenderness is rather emphatic and limited to the vicinity of the ulcer, but it may easily be confounded with a tender gall-bladder, and its diagnostic worth is trivial.

Value of Indirect Signs.—The value of all these indirect signs depends considerably upon their frankness, their varying combination, and their concordance with the general aspects of the case. Hyperperistalsis associated with gastric retention

and an enlarged stomach of normal outline is safely diagnostic, and making multiple plates in such cases is superfluous. Hyperperistalsis alone, if pronounced, is perhaps a 60 per cent. item. Backed by a good clinical history it is worth even more, but there are instances in which this combination results from causes other than duodenal ulcer, so that it is wise to look for other evidence in addition. There is always this to be said of indirect signs, that where they fall short of establishing a diagnosis they contribute to diagnostic certainty, or, at all events, guide the observer in the right line of inquiry.

The examiner may, if he desires, acquaint himself with the clinical history in every case. This knowledge will direct his particular attention to the probable source of trouble and will restrain him from overhasty conclusions. There is no intent to suggest that the roentgenologist should base any diagnosis on the history only, or even chiefly—the clinician can do that. Nor should a contradicting history swerve the roentgenologist when his own evidence is conclusive. No diagnosis can be too strongly fortified, and any gross discordance between the findings from all sources should make the examiner cautious in his opinions. As a corollary of this, he should not pin exclusive faith to any single method of roentgen examination, but should make use of every technic that offers help, and weigh the result as a whole.

Concurrence of Duodenal and Gastric Ulcer.—As mentioned in Chapter XIII, about 11.5 per cent. of the cases of gastric ulcer have a duodenal ulcer also. Hence, the examiner should not be too easily satisfied with the demonstration of a duodenal ulcer, but should make careful observations for a possible gastric ulcer.

Case 127,835, woman, aged 35 years. During the past eight or ten years she has been having attacks of epigastric pain, coming on one to three hours after meals. At first the attacks were not severe and came at long intervals, often to one year. Chronic appendix removed seven years ago; not much improvement. Two years ago she was operated upon for gall-stones, which were not found. Her surgeon told her that he "covered in" an ulcer of the intestine. She was

very much improved for six or eight months. Over a year ago she was treated by lavage and dieting for a gastric ulcer, and gained much relief. Present attack began eight weeks ago. A week ago she vomited two or three times with relief. During the past few months she has lost

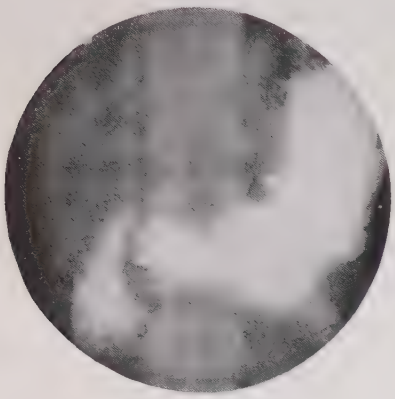

Fig. 430.

Fig. 431.

Fig. 432.

Fig. 433.

Figs. 430, 431, 432 and 433.—Cases illustrating duodenal and gastric ulcer in the same patient.

10 or 15 pounds in weight. Gastric analysis: Stomach empty. Hemoglobin 83. Roentgen findings: Constant deformity of bulb (Fig. 434). Findings at operation: Large, contracting, scarred ulcer of duodenum just below pylorus, with adhesions to anterior abdominal wall and liver. Operation: Posterior gastro-enterostomy.

Case 124,843, man, aged 30 years. Seven years ago he had a sudden attack of very sharp and severe pain in the right hypochondrium, emesis of greenish vomit, and fever, followed by marked jaundice. For a year after this by spells he had subcostal tenderness, aggravated by jolting, together with gas, fullness and sour eructations after meals. For three or four years he had very little trouble. He then began to have attacks lasting a month, of epigastric tenderness with hunger-pain, relieved by light food and aggravated by acids, coffee, tea and meat. Some months ago, for two weeks, he had extraordinarily black stools. For six weeks past he has had fullness for a half hour after meals, then relief for two hours, then hunger-distress. Four weeks ago

Fig. 434.—Case 127,835.

he again had an acute attack of upper abdominal pain with fever, which ceased suddenly, and was not followed by jaundice. At present there is some rigidity and tenderness in the right hypochondrium. Total acidity 76; free 60; combined 16. Hemoglobin 85; leukocytes 11,000. Roentgen findings: Deformity of bulb. Diagnosis: Duodenal ulcer (Fig. 435). Findings at operation: Subacute perforated duodenal ulcer just at the pylorus. Pylorus adherent to left lobe of liver. Adherent appendix. Gall-bladder negative. Operation: Posterior gastro-enterostomy. Pylorus blocked (Wilms). Ulcer covered with omentum. Appendectomy.

Case 128,344, man, aged 46 years. Eight-year history of gastric attacks, coming on once or twice a year and lasting three to ten weeks. In these he has a fullness and distress two and a half hours after meals,

FIG. 435.—Case 124,843.

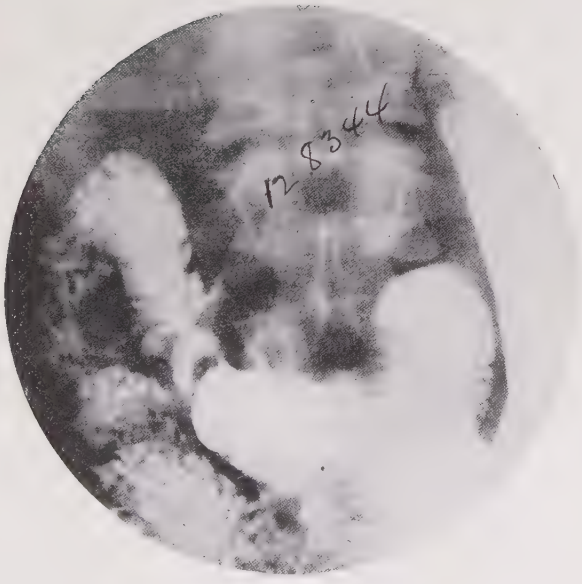

FIG. 436.—Case 128,344.

lasting until the next meal or alkalies are taken. Eating soon after the pain begins increases the distress. Much night distress from 10 p.m. to 2 a.m. Very little belching or sour eructations. Total acidity 66; free 54; combined 12. Roentgen findings: Bulb deformed. Diagnosis: Duodenal ulcer (Fig. 436). Findings at operation: Large, thick, calloused ulcer of the duodenum, anterior wall, beginning just below the pylorus and extending downward 3 or 4 cm. Beginning obstruction. Long mesocolic band. Operation: Posterior gastro-enterostomy. Ulcer covered in with sutures. Mesocolic band divided.

Case 142,380, man, aged 62 years. About three years ago he began having general abdominal pains, worse at the umbilical region, coming usually after bowels had not moved for three or four days, and relieved by catharsis. Never any trouble directly referable to the stomach. Two months ago he had an attack of pain and vomiting, after a constipated period. For two weeks he has had occasional vomiting though bowels are moving. Indefinite history also of heavy feeling at night, relieved by soda, and prevented by taking cathartics. Total acidity 70; free 60; combined 10; no food remnants. Roentgen findings: Retention of half the six-hour meal. Hyperperistalsis. Bulbar deformity. Diagnosis: Perforated duodenal ulcer (Fig. 437). Findings at operation: Large ulcer, anterior wall of duodenum, perforated into head of pancreas, forming tumor 5 cm. in diameter. Operation: Posterior gastro-enterostomy; ulcer covered.

Case 146,943, man, aged 53 years. Thirty-year history of trouble with stomach. Attacks in spring and fall, lasting three months, of cramps two or three hours after meals and at night from 12 to 1. Well between attacks. No food relief; some ease by soda; most relief by drinking water and inducing vomiting. Much sour stomach; some gas. Occasional retention vomit. Qualitative dyspepsia for fats, acids, apples, etc. Frequently tarry stools; never vomited blood. Many years ago had three attacks of severe abdominal colic requiring chloroform for relief. No jaundice, chills or fever. Weight loss, 20 pounds in one month. Total acidity 66; free 52; combined 14; no food remnants. Roentgen findings: Retention of half the six-hour barium meal. Hyperperistalsis. Irregular bulb. Diagnosis: Duodenal ulcer (Fig. 438). Findings at operation: Extensive ulceration of the duodenum. Gall-bladder negative. Operation: Posterior gastro-enterostomy.

Case 134,500, man, aged 38 years. For four years he has had attacks of very sour stomach coming any time in the afternoon or night and accompanied by dull epigastric pain. He forces vomiting for

FIG. 437.—Case 142,380.

FIG. 438.—Case 146,943.

relief. The attacks have no relation to eating, and food does not ease although he has taken a good deal of soda. The trouble is fairly continuous, although he has occasional remissions, even to one month. Three months ago he vomited a large quantity of blood. Operation elsewhere for ruptured appendix three years ago. Weight loss, 27 pounds in two years. Total acidity 90; free 70; combined 20; food remnants. Roentgen findings: Retention of three-fourths the meal. Hyperperistalsis. Small irregular bulb. Diagnosis: Duodenal ulcer

Fig. 439.—Case 134,500.

(Fig. 439). Findings at operation: Multiple ulcers of duodenum, at least three being felt. Large, dilated stomach. One firm adhesion between anterior wall of stomach and gall-bladder. Operation: Posterior gastro-enterostomy. Ulcers enfolded.

Case 144,333, woman, aged 33 years. For two years, following a nervous breakdown at that time, she has had severe epigastric pain, coming on immediately after eating and lasting two or three hours. Some relief by soda. Always feels best with empty stomach. Con-

siderable eructation of acid. For seven weeks past she has had attacks of vomiting, coming on about 1.30 a.m. and preceded by sharp pain in the epigastrium. Absolutely no abatement of symptoms in two years.

FIG. 440 —Case 144,333.

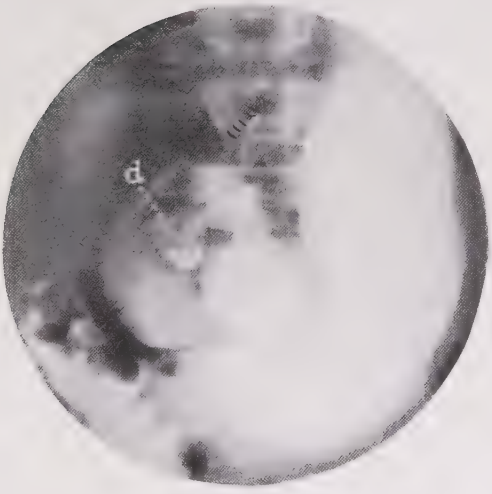

FIG. 441.—Case 111,247.

On liquid diet for six weeks. Strength poor. Weight loss, 5 pounds in two years. Diffuse tenderness upper abdomen. Total acidity 40; free 22; combined 18. Roentgen findings: Constant spastic incisura,

outer aspect of bulb near base. Diagnosis: Duodenal ulcer (Fig. 440). (This case illustrates the fact that a small duodenal ulcer can be present without showing roentgenologically unless it produces spasm.) Findings at operation: Definite smooth scar on duodenum, 1 to 2 cm. below the pylorus, with marked stippling sign. Large stomach and dilated duodenum. White gall bladder with adhesions about it. Definite chronic appendix. Operation: Excision of ulcer of duodenum and closure as a Heinecke-Mikulicz operation. Cholecystectomy. Appendectomy. Pathologic report: Chronic catarrhal cholecystitis (very early "strawberry"). Duodenal ulcer. Chronic catarrhal appendicitis.

Case 111,247, man, aged 25 years. Began three months ago with a sudden, sharp, sticking pain, right costal margin, causing him to double up for a few minutes. Two or three attacks daily. Never vomited or had to go to bed on account of pain. No chills, fever, or jaundice. His physician gave him some pills, after taking which, the patient states, he passed gall-stones. For a month he has had a dull epigastric pain usually with empty stomach, relieved by food of any sort. No gas or sour eructations. Bowels regular; appetite fair. Sleepless and nervous. Total acidity 44; free 30; combined 14. Some tenderness and spasm, right costal margin. Roentgen findings: Diverticulum of the duodenum. Rather large low-lying stomach (Fig. 441). Findings at operation: Duodenal ulcer, 2.5 cm. below pylorus with marked contraction, producing what appeared to be a diverticulum from lower border of duodenum, 4 cm. in diameter. Operation: Posterior gastro-enterostomy. Ulcer area covered in with purse-strings of silk.

Case 167,541, man, aged 42 years. July 31, 1916, the roentgen findings of the stomach were negative; there was deformity of the duodenal bulb. A diagnosis of duodenal ulcer was made (Fig. 442). Feb. 13, 1919, the stomach was negative and the duodenum was fairly regular. The diagnosis was indeterminate (Fig. 443). At operation a small ulcer with very slight stippling on manipulation was found on the anterior wall of the duodenum about 2 to 3 cm. below the pylorus. It was excised without cutting through the pylorus.

Microscopic examination of the tissue from the duodenum showed slight scarring on the mucous surface, probably a healed ulcer. The healed or almost healed condition of the ulcer explained the regular appearance of the bulb on roentgen examination. The ulcer was too small to produce any deformity of contour and there was no spasmodic deformity.

Case 158,555, man, aged 37 years. One year ago he began to have

a gnawing epigastric pain, coming two hours after meals and relieved by food, so that he acquired the habit of eating five or six times daily. The pain gradually increased and he has had to give up his work. No pain at night; no nausea; no vomiting; no hematemesis; no tarry stools.

Fig. 442.

Fig. 443.

For six months, up to a month ago, the patient had a respite from his trouble and gained weight and strength. During the past month, however, there has been no freedom from pain. Weight loss, 9 pounds in one month. Considerable epigastric tenderness. Total acidity

92; free 80; combined 12. Roentgen findings: Three different examinations with a series of plates on each occasion failed to show either a normally filled bulb or a constantly deformed bulb. At operation, the

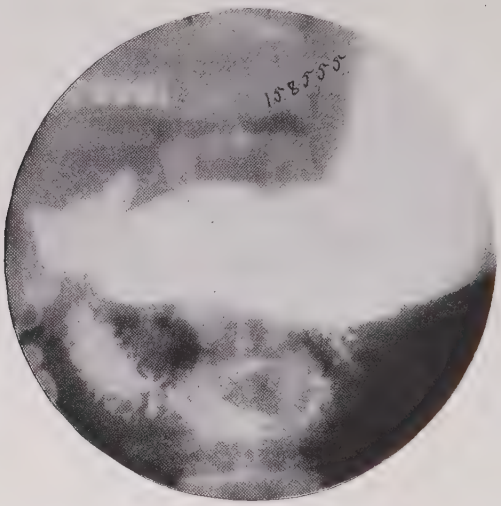

Fig. 444.—Case 158,555.

Fig. 445.—Case 158,555.

duodenum was found to be unusually large, and this probably accounted for the failure to fill it and show its actual contour (Figs. 444 and 445). Findings at operation: Ulcer anterior superior duodena

wall, just below pylorus. Obstruction first degree. Evidence of recent peritonitis. Operation: Posterior gastro-enterostomy. Ulcer enfolded.

Case 158,688, woman, aged 61 years. For many years she has had epigastric pain, gas, fullness, and sour eructations, usually coming directly after meals, and she feels better with an empty stomach. She has to avoid acids, apples, heavy foods and sweets. During the past eight years, about twice a month, she has had pain under the right costal margin and in the epigastrium, often coming about 10 a.m. and lasting the remainder of the day. For three months this has been much more marked, and every night, or twice in the night, she has been

Fig. 446.—Case 158,688.

awakened with a feeling of hunger and weakness, quickly followed by terrific stabbing pain through the right costal margin to back, and lasting not more than five minutes. Stools often light. Weight loss, 16 pounds. Total acidity 50; free 40; combined 10. Hemoglobin 50. Roentgen findings: At the screen-examination an irregular bulb was seen and the case was believed to be one of duodenal ulcer. However, the plates, as here illustrated (Fig. 446), showed an apparently normal bulb and a negative diagnosis was returned. Shortly before coming to the Mayo Clinic, this patient was examined on three occasions by a roentgenologist who found a small retention from the six-hour meal but a negative stomach and duodenum. He concluded that the trouble was probably a lesion of the gall-bladder. Clinical diagnosis: Chronic

cholecystitis. Gall-stones. Findings at operation: Chronic perforated duodenal ulcer, anterior superior wall, beginning immediately below the pylorus. Very extensive adhesions anterior right abdomen.

Fig. 447.—Case 106,481.

Fig. 448.—Case 131,731.

Gall-bladder closely adherent and cause of gall-bladder symptoms. At one time evidently an acute peritonitis and leakage due to perforated duodenal ulcer. Operation: Posterior gastro-enterostomy.

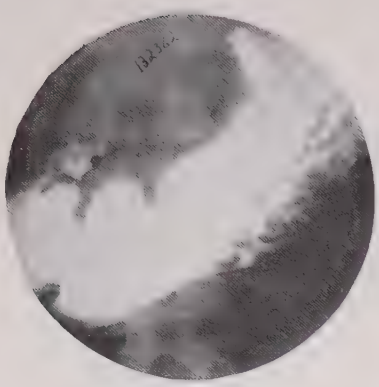

FIG. 449.

FIG. 450.

FIG. 451.

FIG. 452.

FIG. 453.

FIG. 454.

FIGS. 449, 450, 451, 452, 453, 454.—Examples of bulbar deformity in duodenal ulcer.

Fig. 455.

Fig. 456.

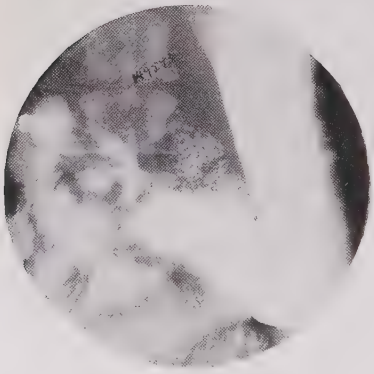

Fig. 457.

Fig. 458.

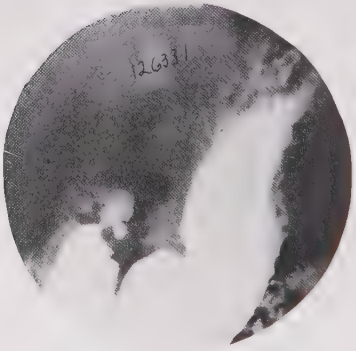

Fig. 459.

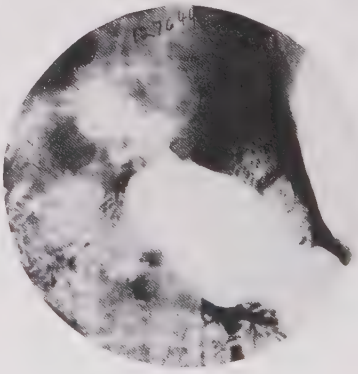

Fig. 460.

Figs. 455, 456, 457, 458, 459, 460.—Examples of bulbar deformity seen in duodenal ulcer.

FIG. 461.

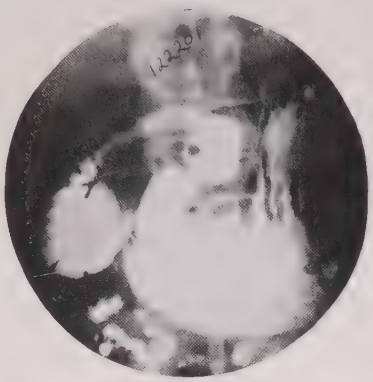

FIG. 462.

FIG. 463.

FIG. 464.

FIG. 465.

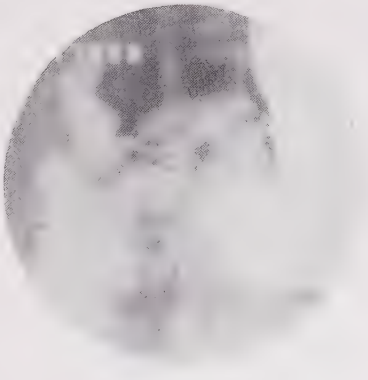

FIG. 466.

FIGS. 461, 462, 463, 464, 465, 466.—Examples of bulbar deformity in duodenal ulcer

FIG. 467.—Markedly deformed bulb. Large third portion of duodenum. Operation: Duodenal ulcer; no other lesion.

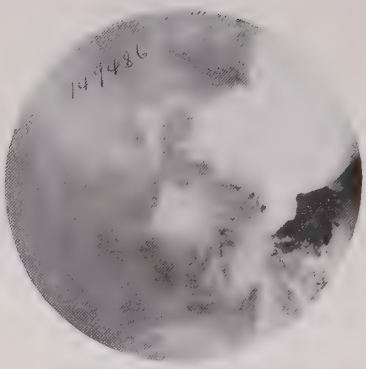

FIG. 468.—Lateral view showing deformed bulb in a case of duodenal ulcer.

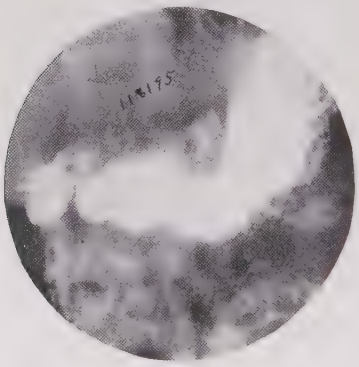

FIG. 469.—Duodenal ulcer; bulbar deformity.

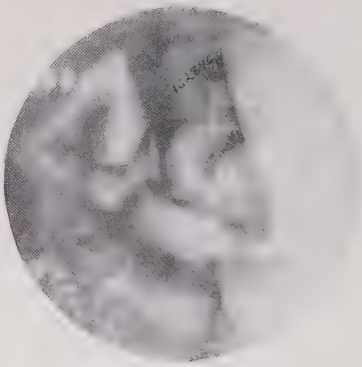

FIG. 470.—Duodenal ulcer. Deformed bulb resembling a Maltese cross.

FIG. 471.—Perforated duodenal ulcer with obstruction.

FIG. 472.—Duodenal ulcer deformity lesser curvature side of the duodenum.

FIG. 473.—Perforated duodenal ulcer with obstruction.

FIG. 474.—Perforated duodenal ulcer with obstruction.

FIG. 475.—Duodenal ulcer with a cluster of gall-stones just above the bulb.

FIG. 476.—Perforated duodenal ulcer.

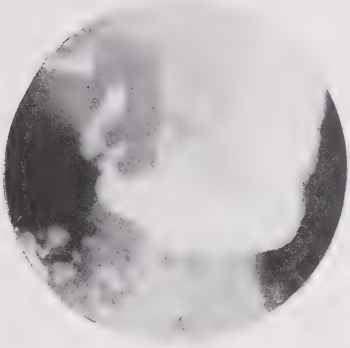

FIG. 477.—Duodenal ulcer with perforation.

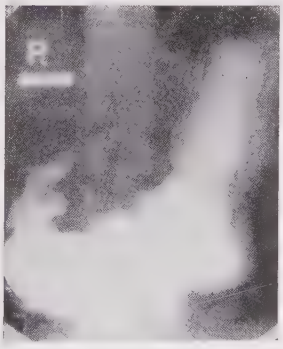

FIG. 478.—Duodenal ulcer showing deformity of bulb.

Case 106,481, man, aged 62 years. For twenty-five years, continuous, severe, burning sensation in epigastrium. Occasionally it is less severe, but he has not found relief by any measure whatever. He has no distinct nausea, but at times he feels as though vomiting might give relief. Lately the burning has become especially severe about 2 a.m. Appetite good, but he does not eat to satiation, as this is followed by distress within a half hour. Weight loss, 9 pounds. Tenderness right costal margin. Total acidity 52; free 34; combined 18. Roentgen findings: Persistent deformity of the bulb. Diagnosis: Possible duodenal ulcer, or adhesions, or both (Fig. 447). Findings at operation: Chronic catarrhal cholecystitis. Gall-bladder very adherent. Liver adherent to abdominal wall. Pylorospasm. Operation: Cholecystectomy.

Case 131,731, man, aged 37 years. During the past fifteen years he has had gastric distress, gas and sour eructations almost continuously, never being entirely free for a day, and worse in winter. The discomfort comes on a half hour after breakfast and becomes severe from 9.00 to 11.30 a.m. It is relieved by the noon meal and recurs at 1.00 p.m. Every morning at 3 or 4 o'clock he is awakened by it. Besides relief by food he obtains partial relief by soda, belching, hot water, etc. Never vomits; no black stools. No weight loss. Succussion over stomach; tenderness of epigastrium. Total acidity 60; free 46; combined 14; no food remnants (twelve-hour meal). Eight-hour motor meal shows small amount of food remnants. Roentgen findings: Large hypotonic stomach. Retention of half the six-hour meal. Normal gastric and bulbar contours (Fig. 448). Negative diagnosis. Clinical diagnosis: Duodenal ulcer with obstruction. Findings at operation: Pyloric obstruction due to an extensively adherent gall-bladder, which is firmly bound to the abdominal wall. Stone 2 to 3 cm. long in tip of appendix. Operation: Cholecystectomy. Appendectomy.

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CHAPTER XXI

MISCELLANEOUS LESIONS OF THE SMALL INTESTINE

Besides the bulbar diverticulum incident to obstructive duodenal ulcer, and the accessory pocket, or pseudo-diverticulum of perforated duodenal ulcer, diverticula may also occur in the neighborhood of the ampulla of Vater. They are chiefly of academic interest. I have never found any roentgen literature on Meckel's diverticulum, nor have I recognized one roentgenologically. Other than duodenal ulcer, the only important condition of the small intestine which is readily susceptible of demonstration by the x-ray is obstruction from various causes.

Judd[1] found, in the postmortem reports from a large number of clinics in which many thousand cases were examined, that carcinoma of the small bowel comprised about 3 per cent. of all the cancers of the gastro-intestinal tract; whereas in the Mayo Clinic carcinoma has occurred twenty-four times in the small bowel (less than 1 per cent.) as compared with 1822 times in the large bowel and rectum, and 1689 times in the stomach.

In Judd's series of twenty-four cases, cancer occurred five times in the duodenum, eleven times in the jejunum and six times in the ileum, and in two cases the lesions were multiple.

CANCER OF THE DUODENUM

These tumors occur regularly in one of three parts of the duodenum—supra-ampullary, ampullary and infra-ampullary. About 70 per cent. of all cancers of the duodenum are located at the ampulla. This is beyond the bulb or ulcer area and since valvulæ conniventes occur normally in this portion of the duodenum and give an irregular serrated outline to the barium shadow, lesions could hardly be recognized except at points

where they produced obstruction. These facts would apply also in the infra-ampullary portion of the duodenum. Cancer in the supra-ampullary area is not to be differentiated roentgenologically from ulcer. But, since it has only been seen five times in four thousand operative cases of duodenal ulcer, a failure to diagnose it should be forgiven. The x-ray was used in three of the five cases of carcinoma of the duodenum. In the first one the colon only was examined. In the second case the roentgen findings of the stomach and duodenum were indeterminate. In the third case the finding was duodenal ulcer.

Carcinoma of the jejunum is more common than cancer either of the duodenum or ileum. The x-ray was employed in five of the eleven cases of carcinoma of the jejunum. In the first case the lesion was located accurately. In the second a diagnosis of cancer of the stomach was made. In the third case the ray showed a No. 2 retention in the stomach at the end of six hours; a mass chiefly, if not wholly, extrinsic, was palpated which, together with distention of the upper small bowel, evidenced obstruction. In the fourth case the x-ray examination of the stomach and colon was negative. This was also true of the fifth case.

Two of the six cases of carcinoma of the ileum came to roentgen examination. In the first one the x-ray findings were: Hour-glass stomach, and obstruction at the pylorus. In the second case the x-ray showed the classical roentgen picture of obstruction of the small intestine. The pathology, symptomatology, and the roentgen findings of carcinoma in the ileum are practically the same as those found in carcinoma of the jejunum.

While the roentgen findings in these few cases might lead one to believe that the x-ray is of little value in demonstrating these lesions, it should be remembered that nearly all of the cases were examined early in our work when the interpretation was not so well understood as it is at the present time. Recent cases demonstrate that when the obstruction is fairly marked the roentgen findings are quite characteristic and often furnish

valuable aid to the surgeon in the more definite localization of the tumors, whether they are high, low or midway in the intestines.

The most important and constant x-ray finding is the gas and fluid distention of the bowel. The fluid may show hydrostatic levels in the various loops. The amount of gas, fluid and distention will depend on the degree of obstruction and on the location of the lesion; it is greatest in the low obstructions. The valves of Kerkring, unlike the folds in the stomach, are permanent and are not obliterated by distention of the intestine. This may be easily proved by roentgen examination after the opaque meal, when the outline of the valves can be seen, and is one of the findings which enables the examiner to decide that distention of the intestine is present. Tumors high in the small intestine may show a six-hour retention in the stomach. There may be a distinct residue just proximal to the point of obstruction. The average time of passage from the stomach to the cecum is from three to six hours. If no barium has passed into the cecum after six hours and barium is found high in the small bowel (even without dilatation), this should be regarded with suspicion. The intestines are in a state of unrest, due to vigorous peristalsis and antiperistalsis.

Instances of obstruction from the different causes are presented in the following case reports.

Case 143,715, male, aged 59 years. The patient complains chiefly of numbness of the extremities and gastric distress. About eight months ago he had a rather sudden onset of numbness of the distal phalanges—both hands. With this was a numbness of the toes which has extended up the inner side of his legs and to his body as far as the umbilicus. For a year he has had attacks of gastric distress lasting a week or ten days, coming three hours after meals and at midnight. Relief obtained by soda and by vomiting. Some gas and sour eructations. He vomits at irregular intervals, sometimes the entire meal taken six hours previously. No hematemesis or tarry stools. Some qualitative food dyspepsia for acids, apples, etc. Weight loss, 12 pounds. Anemic. Knee-jerks absent. Hemoglobin 55 per cent. Gastric analysis: Total acids, 10; all combined; no food remnants.

Endamœbæ histolytica in stools. Urinalysis negative. Roentgen findings: No retention from the six-hour meal. Fairly active peristalsis. No normal bulb, but deformity inconstant at two extensive

FIG. 479.—Case 143,715.

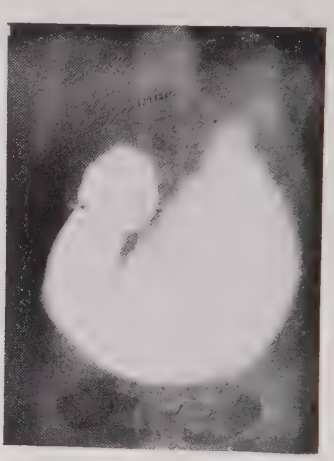

FIG. 480.—Case 139,141.

FIG. 481.—Case 77,400.

FIG. 482.—Case 77,400.

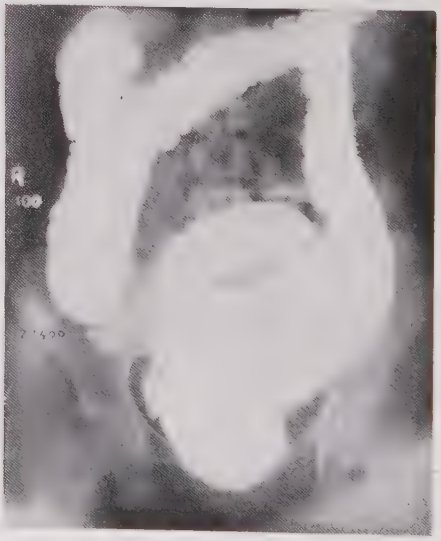

FIG. 483.—Case 77,400.

examinations (Fig. 479). Diagnosis: Indeterminate. After medical treatment, the patient went to his home. He returned to the Clinic about nine months after with his gastric symptoms aggravated, an icterus of seven months standing and marked weight loss. Transfu-

sion. Exitus lethalis. At the second visit of the patient, when the x-ray might have shown the site of obstruction, no roentgen examination was made. Necropsy report: Carcinoma of the duodenum which involves the head of the pancreas and partially occludes the common bile-duct. Small hypernephroma of the left adrenal. Moderate fatty degeneration of liver, etc.

Case 139,141, woman, aged 51 years. Several years history of occasional epigastric pain, soon after meals; sometimes forced vomiting for relief. The attacks were brief and came at intervals of several months. One year ago she had an unusually severe attack which necessitated morphin for relief, and again three months ago. Since then she has had much epigastric distress and pain in stomach after taking food, with burning, gas, and bitter eructations. Every second day or night she vomits large quantities of food and bitter fluid. Weight loss, 30 pounds. Peristalsis well marked. Total acidity 18; free 0; combined 18; food remnants; filtrate 800 c.c. Roentgen findings: practically entire six-hour meal retained in stomach. Large stomach and duodenum. Pyloric canal widely open. Stomach and bulb normal in outline (Fig. 480). Diagnosis: Obstruction in duodenum beyond the bulb. Findings at operation: Cancer of gall-bladder which had perforated against duodenum about 10 cm. from the pylorus, causing contraction at that point and dilatation of duodenum above. Widely open pyloric ring. Huge, dilated stomach. Operation: Impossible to remove cancer because of involvement of deep structures, ducts, etc. Anterior gastro-enterostomy. Pathologist's report: Specimen shows carcinoma. Necropsy report: Carcinoma of gall-bladder associated with cholelithiasis (one stone), cholangitis, etc.

Case 77,400, woman, aged 36 years. Trouble with stomach since girlhood, six or eight times a year. Cramps in epigastrium, not always related to food, much gas and rumbling in abdomen, occasional vomiting. For three months past she has had a diarrhea with seven or eight watery movements daily. Severe abdominal cramps. Visible and audible peristalsis. Stool examination: Red blood corpuscles, pus; otherwise negative. Wassermann negative. Roentgen findings: One-fourth motor meal in stomach at six hours. Stomach deformed by distended loops of small bowel. Small bowel markedly dilated, containing fluid and gas. Diagnosis: Obstruction of small bowel (Fig. 481). The colon, examined by clysma, shows a redundant sigmoid; the appendix is visible. Otherwise negative (Fig. 483). Findings at operation: Localized hypertrophic tuberculosis involving 25 cm. of the jejunum, about 180 cm. from its origin. Considerable involvement of mesentery. Obstruction of the bowel is marked, the

canal being cicatricial and filled with granulation tissue. Above the obstruction the bowel is enormously distended. Operation: Resection 30 cm. of jejunum; lateral anastomosis. A photograph of the pathologic specimen is shown in Fig. 482.

Case 253,143, a man, aged 25, was examined Dec. 11, 1918. The patient came to the clinic complaining of pain in the stomach, which came on from one-half to two hours after meals, and was relieved by vomiting, beer, or water. The pain at night came on after midnight, with vomiting. There was no hematemesis; the bowels were regular. The roentgen examination showed number one retention at the end of six hours; the stomach was slightly enlarged with active peristalsis,

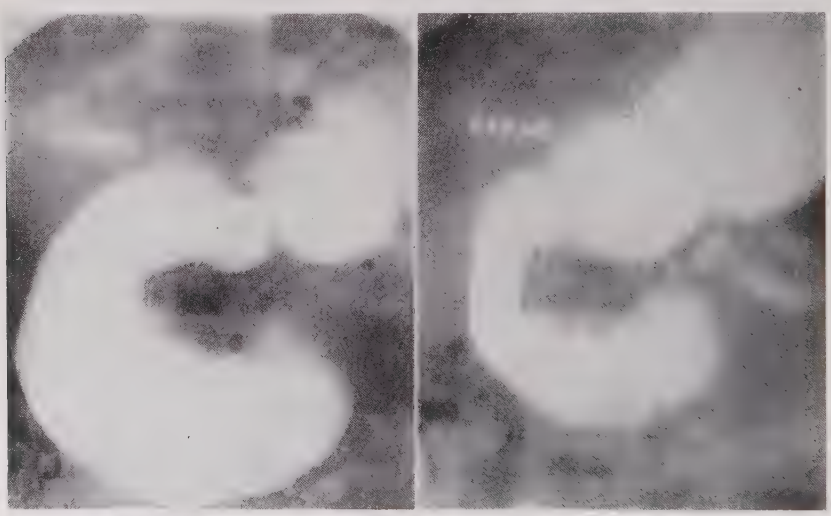

FIG. 484.

otherwise negative. The duodenum was tremendously enlarged, with obstruction at the duodenojejunal juncture. Peristalsis was vigorous, and antiperistalsis was marked. A diagnosis of obstruction of the small intestine at the duodenojejunal juncture was made (Fig. 484).

Posterior gastro-enterostomy and appendectomy were done. A mass of caseating tuberculous glands was found causing obstruction at the duodenojejunal juncture and the entire peritoneum was showered with small tuberculous nodules. The cecum and ileum were negative. The patient was given Coolidge tube treatment over the abdomen.

Case 120,591, man, aged 60 years. Nine months ago he first noticed loss of appetite and occasional slight cramping pain in abdo-

men. Later he began to have spells of vomiting, usually at night. The vomitus was light-colored and watery, as a rule, but on one occasion it was cherry-colored, and at another time dark and foul-smelling. The vomiting came at intervals of eight or ten days, was preceded by constipation, and followed by diarrhea. At present his appetite is fair and food seems to agree, but he has some epigastric discomfort. Weight loss, 30 pounds. No masses palpated; rectal shelf free. Roentgen findings: Obstruction at ileocecal valve (Fig. 487). (No examination of colon by clysma.) Findings at operation: Extensive

Fig. 485. Roentgenograms showing dilated loops of small intestine. Operative findings: Inoperable ring cancer of the small bowel beginning in the jejunum.

carcinoma involving cecum, ascending colon and portion of transverse colon. Operation: Resection of 25 cm. of the ileum, cecum, ascending colon and one-half of the transverse colon. Lateral anastomosis. Pathologist's report: Carcinoma. No glandular involvement found.

Case 85,886, man, aged 43 years. Ten months ago he had an attack of cramping pain, three or four hours after a meal, which was relieved only by induced vomiting. Six weeks later he had a similar attack and later others, at intervals of three or four weeks. For four months the trouble has been practically continuous. Pain comes an hour and a half or more after eating and is not relieved until he

induces vomiting. He frequently brings up bile and large quantities of foul material. Recently he has resorted to lavage and he is sometimes able to retain small amounts of fluid and soft food. Former weight 168; present 114. Gastric analysis: Total acidity 50; free 40; combined 10; food remnants. Small floating mass palpable to right of umbilicus. Roentgen findings: Although the examiner, who was

Fig. 486.—Roentgen examination of the stomach. No. 2 retention from the six-hour meal. Stomach otherwise negative. Barium in masses throughout the small intestine, with gas distention. Colon ray shows filling defect in the cecum. Operative findings: Chronic intussusception in the ileocecal coil. Tumor the cause of obstruction; the small bowel tremendously distended.

at that time inexperienced, made a diagnosis of gastric cancer, the roentgenogram (Fig. 488) shows the typical signs of obstruction of the small bowel. The intestine is enormously distended and deforms the stomach by pressure. The markings of the valvulæ conniventes are clearly visible in the gas and fluid distended bowel. Findings at operation: Ring carcinoma, upper small intestine. Metastatic nodules in omentum. Operation: Entero-anastomosis between distended and collapsed loop of bowel.

Case 86,605, man, aged 57 years. Following an attack of diarrhea nine months ago, the patient lost appetite and began to vomit occasionally two or three hours p.c. The vomiting is preceded by soreness at the right costal margin. During the past week he has been worse, with epigastric distress several hours p.c., followed by vomit-

Fig. 487.—Case 120,591.

Fig. 488.—Case 85,886.

Fig. 490.—Case 86,605.

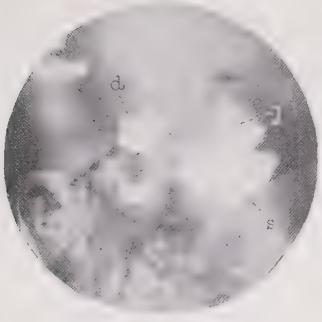

Fig. 489.—Case 86,605.

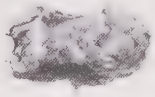

Fig. 491.—Case 86,605.

ing of sour, bitter fluid. Never food-ease. Usual weight 150; now 132. Total acidity 48; free 40; combined 8; food remnants; sarcinæ. Movable, tender mass low in the right epigastrium. Roentgen findings: Gastric retention of half the six-hour meal. Retention also in duodenum and loop of upper small bowel, which latter is high up behind stomach, and shows a collection of gas at point of obstruc-

tion (Fig. 489). After filling the stomach the collection of barium in the small bowel was obliterated in the gastric shadow (Fig. 490). The gas-bubble at the point of obstruction could still be seen. Findings at operation: Spool carcinoma upper jejunum, lumen 1 cm. in diameter. Operation: Resection upper jejunum, end to end anastomosis by suture. Jejunostomy for feeding. Pathologist's report: Carcinoma. Glands inflammatory. Pathologic specimen, Fig. 491.

REFERENCE

1. Judd, E. Star: "Carcinoma of the Small Intestine." *Journal-Lancet*, 1919, xxxix, 159–169.

CHAPTER XXII

THE LARGE INTESTINE

Technic.—In the examination of the colon either the ingested meal or the clysma, or both, may be employed. Of the two, the clysma is the more important and the more commonly used in the Mayo Clinic, although the meal is indicated when the determination of motility is chiefly desired and when stenotic conditions completely obstruct the enema, which thus fails to show the proximal limits of an obstruction.

A convenient meal is a cereal with barium, such as is used in the examination of the stomach. When motility (stasis, etc.) is to be investigated especially, the meal should be given without previous purgation and the patient should continue his usual habits as to eating and exercise in order that the customary conditions may be maintained. Four to six hours after ingestion, with normal motility of the stomach and small bowel, the meal will begin to enter the cecum and the examination may be commenced. The combined screen and plate examination is preferred, and should be repeated at set intervals until the meal is evacuated.

When the clysma is to be employed, preliminary preparation of the patient is necessary. He should take 30 to 60 gm. of castor oil on the evening prior to examination, should abstain from the evening meal, and should clear out the bowel with a plain or soapsuds enema next morning before coming for the test. He may take a light breakfast if desired. The vehicle for the opaque clysma may be fermented milk, potato-starch pap, mucilage of acacia or some similar medium, and either barium or bismuth may be used. The clysma which we are accustomed to use is prepared by stirring 250 gm. of barium sulphate into 500 c.c. of mucilage of acacia and adding to this the contents of two or three cans of condensed milk to make a total

of 2 liters. Occasionally this mixture will be rather too thick to flow freely and may be thinned with a little water. The consistency should be that of a heavy cream. The clysma should be warmed to about body temperature. The enema-container, preferably of enameled ware, should be attached to a rope running over an elevated pulley, so that it may be raised and lowered as desired (Fig. 492). The rubber inflow tube should be 8 or 10 feet long, equipped with a spring-clip cut-off, and tipped with a self-retaining syringe-nozzle having a large

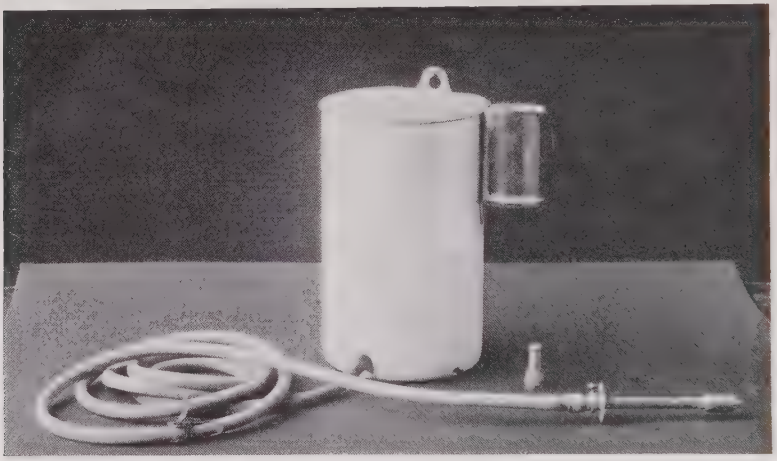

FIG. 492.—Enema can, showing small detachable receptacle for receiving metal nozzle, after withdrawal from the rectum. The nozzle is detachable for sterilization.

opening. The air should be driven out of the tube by permitting the enema to flow for a moment before it is introduced into the bowel. It may be mentioned that the so-called high enema tube is quite unnecessary for filling the bowel; it simply curls up in the ampulla without entering farther.

The patient, stripped to his hips, lies on his back on the screen-table. The tip of the inflow tube, anointed with vaseline, is introduced into his rectum. When all is ready, the room-lights are turned out and the spring-clip is released. As a rule, the enema rather slowly fills the ampulla, which expands to accommodate its increasing contents. Throughout the bowel the filling process is not usually seen as a steady advance of the

clysma, but is rather irregular; a section of the bowel is invaded by a tongue of the oncoming stream and then filled out to its capacity, after which another tongue is pushed forward. Frequently there is a little delay, real or apparent, at the flexures. After a flexure is passed, the proximal portion of the bowel may fill rapidly. Complete filling will ordinarily take place in from three to ten minutes. In most instances some of the enema will pass beyond the ileocecal valve into the ileum. If the patient complains of pain at any time, the spring-clip may be closed or the container lowered until the discomfort ceases. The container at a height of 3 or 4 feet above the patient is usually practicable.

While the colon is filling, the screen observation should be made either continuously or at frequently repeated intervals. Palpatory manipulation is quite essential in the investigation of eccentric appearances. If the patient's abdomen is rigid, it may be relaxed by having him flex his thighs and breathe with his mouth open. The tube and screen should be shifted about so that the particular region to be inspected will be in direct line with them, thus avoiding distortion of the shadow. Turning the patient to one side will change the angle of the rays and help in the study of apparent kinks and angulations. The diaphragm should be adjusted from time to time to permit close inspection of suspicious localities.

Plates 14 by 17 inches are best made with the intensifying screen during suspended respiration. The lower edge of the cassette should project 3 or 5 cm. below the plane of the pubic arch. The tube distance should be from 50 to 75 cm. At least two of the plates should be made with the patient in the prone position, and others with the patient supine. Both screening and plating with the patient standing may occasionally be advantageous to show changes of position. When plates only are desired, it is more convenient to give the enema with the patient lying on either side, with his knees drawn up, rather than on his back. The old time knee-chest and Trendelenburg postures are awkward, embarrassing and unnecessary.

When the examination is completed, the patient may go to a closet and empty the bowel. Haenisch[1] withdraws the enema through the tube to prevent subsequent difficulty of evacuation. This is a splendid procedure and should be resorted to in all cases of megacolon or in dilated atonic colons where large quantities of the enema have been used. For several hours after a proctoscopic examination, a patient may have difficulty in retaining the enema during the roentgen examination. In these instances it is better not to undertake the latter examination until the following day.

THE NORMAL COLON

Like normal stomachs, normal colons have by no means a constant appearance as seen in the radiologic picture. Colons which functionate properly and which are proved by exploration to be without lesions often show widely diverse roentgenologic characteristics, especially to the casual view. A description of the normal colon must therefore be limited to certain common types and a few fundamental points of similarity, with a liberal allowance for exceptions. Broadest at the cecum, where it is often a handbreadth, one common type of adult colon narrows slightly but progressively to the sigmoid flexure, from which it opens into the expansible ampulla. From the ampulla descends the tapering rectal pouch. The apparent diameters depend largely upon the degree of distention, but with a 2-liter clysma the descending colon and sigmoid appear to be one-third to one-half the breadth of the cecum. In other cases, the disparity between the broadest and the narrowest part of the colon is much less marked, the effect perhaps of the local tone condition at the moment. Perfectly normal colons are also often seen in which the diameter is practically uniform from the cecum to the splenic flexure.

Position.—Normal variance as to position is especially noteworthy. Closely fixed only at the hepatic and splenic flexures and at the rectum, the colon, between these points, has considerable latitude of passive movement. The position as seen

at any single examination is subject to modification by the position of the patient, whether standing or reclining, the tonus of the colonic musculature, the length of colon between fixed points, and perhaps to some slight extent by the weight of the colonic content. Disparity between the heights of the splenic and hepatic flexures is usually marked. The hepatic flexure is about at the level of the first lumbar vertebra, 2 to 5 cm. above the iliac crest line, while the splenic flexure is close up under the left diaphragm. Occasionally, the hepatic flexure may be at a higher or lower level, but the splenic flexure is rarely displaced except by pathologic causes. The cecum is usually in the right iliac fossa, its lower border level with the sacral promontory, but it may lie well down in the pelvis.

By reason of redundancies, which are not necessarily pathologic, the transverse colon and sigmoid flexure, occasionally also the descending colon, may be so looped and placed as to give various configurations. A long, lax transverse colon may sag to the pelvis, producing imitations of various letters of the alphabet. The sigmoid flexure is especially variable in length and position. When long, it may show as a tangled festoon, or a single long loop may ascend well up out of the pelvis. The descending colon is also sometimes long and looped upon itself. In children, the colon often forms an oval, the transverse colon being high and arched, and without any clearly marked hepatic flexure. Very rarely this may be found in adults. Hurst states that although the ascending and transverse colon of the new-born is quite short, the whole length of the colon is three times the length of the infant, due to the relatively excessive length of the pelvic colon.

It is almost superfluous to say that positions and configurations may vary at successive examinations, and the picture seen with a patient standing may be quite different from that seen when he is recumbent (Figs. 493, 494, 495, 496).

Contour.—During and immediately after the administration of the enema, the colon, while somewhat sinuous, usually has a relatively smooth contour, with few or no sharply marked

indentations or indefinite shadings. Soon after the filling process is completed, however, with the institution of general tonic contraction, the scalloped appearance due to haustration is seen.

Fig. 493.

Fig. 494.

Fig. 495.

Fig. 496.

Figs. 493, 494, 495, 496.—Normal colons.

The haustra are especially emphasized in the descending and transverse portions; later in the different segments of the bowel the haustra become more accentuated or relax slowly from time

to time. A sharply angular indentation of the cecum is generally seen at the ileocolic juncture and there may be a corresponding indrawing opposite. In the rectum the valves of Houston (Heister) sometimes produce one or more acute, unilateral indentations. As seen with the ingested meal, the haustral sacculations of the colon are much more emphatic than with the enema, and the barium in segments between haustra may be narrowed to a thin ribbon, so that the examiner may be inclined to suspect a stenosis. Usually the meal does not preserve its continuity unbroken, but is separated into detached portions.

Capacity.—The capacity of the adult colon depends not only upon its length, but also upon the tone of its musculature. The amount required to fill it within the limit of comfort ranges ordinarily from 1 to 2 liters. When it is hypertonic and spastic, a much smaller quantity will visualize it throughout than when it is relaxed and atonic.

Mobility.—An important feature of the normal colon is its mobility by palpatory manipulation excepting at its three points of fixation, although even the hepatic flexure is ordinarily susceptible of slight shifting. The splenic flexure is not only fixed by its suspensory ligament, but is also sheltered from palpation by the thoracic cage. The lower sigmoid, protected by the pelvis, cannot be easily shifted about. In women, gynecologic palpation may be of service. A tense abdominal wall greatly hinders manipulation of the colon and this feature must be duly considered.

Peristalsis.—Although numerous studies of the peristaltic movements of the colon have been made, the conclusions drawn have been somewhat contradictory, and this function is not as yet well understood. One feature of peristaltic activity which, though rarely seen directly, has been generally accepted, is a rapid propulsive movement *en masse* of a large portion of the colonic content, occurring at infrequent intervals. The rarity of its observation is shown by the fact that Holzknecht,[2] who first noted it, saw it but twice in 1000 cases examined for five

to fifteen minutes. The movement occupied only a few seconds of time, and Holzknecht was at first of the opinion that it occurred only about three times in twenty-four hours, although he has later come to the belief that it occurs oftener, perhaps six or eight times daily. In the cases which he saw, about one-third of the contents was suddenly driven forward a distance equal to its own length. Similar findings have been made by others and an analysis of the movement has been attempted. Jordan[3] has noted that when a wave starts, the part in front loses its haustral sacculation, becoming smaller but smooth by toning up of the muscular fibers. The advancing wave consists of a very firm contraction of the circular fibers, each fiber contracting in its turn and remaining strongly constricted for many minutes after the wave has passed. The rear end of the wave is sharply conical. It is stimulated by the taking of meals, by defecation, irritation (colitis) and emotion. Schwarz[4] holds that it may be excited by the discharge of a large quantity of chyme into the colon as the result of increased gastric and intestinal peristalsis. The wave is more or less perceptible subjectively. He believes that the segment in front of the wave is not contracted, but is dilated.

Other than this massive movement, which has been seen infrequently, but definitely, observers have described a variety of minor peristaltic phenomena. Haustral segmentation, which Holzknecht claims has nothing to do with peristalsis except to retard it, complicates the matter. However, Rieder concluded from plate studies that there are four kinds of movements: Peristalsis, antiperistalsis, oscillating movements, and uniform tonic contractions. Schwarz,[5] examining after an ingested meal, observed a rocking back and forth, mixing movement (wiegephänomen) and regular rapid constrictions. Interval examinations every three to five minutes showed alterations of contour which were greatest in the cecum and ascending colon and grew progressively less marked distalward. The waves he saw traveled both oralward and analward from a fixed point, making a flattened depression lengthening in each direction. This

peculiarity of the wave perhaps accounts for the frequent observations of antiperistalsis by others. Conceding its existence, it must not be classed with gastric antiperistalsis, which latter is seen as a strictly pathologic manifestation. As to this, Schwarz[6] says: "At this point I may advert to the oft-recurring question as to the presence of antiperistalsis in the colon. Whether the retrograde transport results from an actual antiperistalsis or rather from a passive backflow behind a forward advancing constriction-wave cannot be decided without further data. In my opinion the retrograde transport in the colon is most commonly the result of a passive backflow, brought about by a hindrance to the progressing mass, whether this hindrance be a strongly contracted, filled, gas-distended or organically stenosed portion of the intestine. One has only to recall how in an esophageal stenosis, with waves going toward the cardia, the food-mass is forced upward. I have already pointed out that active small movements can shove the intestinal content backward when there is a lessened tonus in this direction. The rocking back and forth after a clysma is apparently not due to an antiperistalsis, but a backswing from powerful, broad, forward-going contractures. In this I am of one view with v. Bergmann and Lenz. However, on one occasion with the enema I was able to see indubitable antiperistaltic action in the colon. Anyway, discussion as to whether there is antiperistalsis or not has no very great significance. Certain is it that retrograde stool-movements occur in the colon, and take place normally. With this we must at present be contented."

Barclay[7] has twice seen massive movements, but he is frankly skeptical as to the lesser waves. He says: "It is evident that the slow peristalsis which used to be described never takes place —at any rate, we never see it—and the only change we do see in the shadow is that occasionally a small bolus rolls from one saccule to another in a manner that is more suggestive of the action of gravity than of the normal passage of feces."

A comparison of the observed movements of the colon with those of the small bowel shows similarities which are not sur-

prising when it is recalled that these organs are not wholly independent but parts of a continuous tube. The rhythmic segmentation of the small bowel has its analogue in the haustration of the colon, and both apparently have two forms of ortho-peristalsis—slow and rapid. However, in the course of a routine examination, the observer is not likely to see any peristaltic activity of the colon at all comparable to that of the stomach. By close study of the screen-image or of successive plates, he may note local changes of contour, but he will seldom be able to trace the progress of any single contraction.

Motility.—The normal motility of the colon as shown by the rate of progress of opaque ingesta through it, is hardly subject to exact determination, because of the numerous varying factors which enter into the matter. Yet an attempt at this determination may be of value, provided the observer interprets his findings liberally and without strict adherence to set rules.

Hurst[8] suggests the following as an average time-table for the "head" of the ingested meal:

Cecum	4 hours
Hepatic flexure	6 hours
Splenic flexure	9 hours
Pelvic colon (sigmoid)	12 hours

From this point on, the rate of progress will depend upon the time and frequency of stooling, and as this occurs ordinarily once daily, a twenty-four hour variation is easily possible under normal conditions. Twenty-four to forty-eight hours is regarded by many roentgenologists as a fair time basis for the passage of bariumized food through the digestive tract. This would allow twenty to forty-four hours for its journey through the colon; but these figures are applicable only on the condition that the patient has not been subjected to recent drug-action and that he pursue normal and accustomed habits as to eating, drinking, exercise and stooling. Nor must absolutely complete evacuation be expected within two days or even longer. Holding[9] has remarked that the fecal current is like any other current; the center moves faster than the sides, and remnants

of bismuth are seen for many days after the bulk of it has been expelled. After a partial evacuation, the remainder of the barium or bismuth is often seen irregularly distributed through

FIG. 497.

FIG. 498.

FIG. 499.

FIG. 500.

FIGS. 497, 498, 499, 500.—Normal colons.

the bowel, and these local accumulations are not necessarily indicative of obstruction distal to them, nor of functional impairment.

THE ABNORMAL COLON

Position.—Other than the variations of position which may occur normally, definite displacements or anomalies of situation are sometimes encountered. In association with general visceral transposition, *situs transversus* of the colon is occasionally seen, the cecum and ascending colon lying on the left side, and the descending colon on the right. In one of our cases the colon alone was transposed. Most radiographers indicate one side of the plate with a leaden R or L, or habitually apply the number to a certain side. Carelessness in this respect might be a source of error where plates only are made.

Arrest of developmental migration may result in a high-placed cecum, or the entire colon may still lie to the left of the vertebral column—so-called non-rotation. By failure of the cecum and ascending colon to rotate on their long axes, the ileocolic juncture may be found on the outer aspect of the cecum, instead of the inner.

Displacement of any part of the colon may be produced by extrinsic tumors of every sort, including those of the liver, kidney, pancreas, spleen, uterus, and adnexæ, by adhesion bands, by pregnancy and by psoas abscess. Displacements ordinarily affect only those portions of the colon which are more or less movable normally, the hepatic flexure being occasionally, and the splenic flexure rarely, implicated.

Whatever may be the final decision with regard to the debatable question of ptosis and its importance, it can hardly be doubted that this term has been abused in connection with the colon, and especially its transverse portion. With a little increase of its length, the transverse colon may easily have its middle portion down in the pelvic basin, whether its possessor is asthenic or not, and to label this condition as ptosis is certainly unfair. On the other hand, there may be marked, evident and actual displacement downward of the colon, and the position of the flexures is a better criterion of this than the position of the transverse colon. The hepatic flexure may be well below the iliac crest and even the splenic flexure may be slightly dropped,

although this is quite uncommon. In decided enteroptotics nearly the entire colon may be huddled together in the pelvic basin (Fig. 501). In judging position, apparent displacement due to obliquity of the rays must be borne in mind.

Contour.—Irregularities of contour—filling-defects—may be produced by intrinsic tumors, diverticulitis, or bands of adhesions. Apparent filling-defects may be caused by fecal

FIG. 501.—Coloptosis.

matter, fecaliths, gas, localized spasm, extrinsic tumors, insufficient quantity of the enema, or the pressure of adjacent bony parts such as the spine and pelvic brim.

The coils of the sigmoid farthest from the screen or plate often seem vaguely shadowed. Movement of the patient or slight shifting of the bowel may make what seem to be filling-defects on the plate.

Sharp angulation may be due to actual kinking; more often, however, it will be found that this appearance is due to the angle at which the loop is viewed. According to Jordan,[10] the points of election for kinks in the colon are the hepatic flexure, the

proximal portion of the transverse colon, and the sigmoid. Hurst[11] has seen but one case of kinking with partial obstruction and this was located at the splenic flexure. He also cites a case of Frank's in which a mobile left kidney adherent to the splenic flexure caused a kink of the latter.

Mobility.—Abnormally increased mobility of the cecum and ascending colon has been noted in the *cecum mobile et atonicum* of Wilms in association with tenderness and dilatation. With increased length of any segment between suspension points, there is a corresponding increase of its mobility.

Diminished mobility, even to complete fixation, is a common sequence of adhesion-producing pericolic inflammations. More or less fixation of the cecum may be the result of appendicitis, tuberculosis, pelvic conditions or malignancy. In cases of so-called Jackson's membrane, the proximal half of the transverse colon has been found ptosed and parallel with the ascending colon and inseparable from it. Adhesions from a pericholecystitis or a perforated duodenal ulcer may more firmly anchor the hepatic flexure or attach it to the pyloric end of the stomach. Carcinoma of any part of the bowel, whether primarily intrinsic or extrinsic, may fix it. The sigmoid flexure may be fixed by pelvic inflammations of any sort.

In regard to adhesions generally—and this applies not only to the colon but to the entire gastro-intestinal tract—it may be said that one of the hardest lessons the roentgenologist has to learn is that juxtaposition of the viscera does not necessarily mean that they are adherent to each other, but, on the contrary, are rarely so. In repeated instances in which adhesions were suspected, or when the diagnosis of adhesions had been made by others, surgical exploration has shown either no trace of them, or, if found, they were not where they were thought to be. The diagnosis of adhesions or their emphasis in a roentgenologic report, is not, as a rule, highly appreciated by the surgeon or internist. Both are likely to feel that a serious pathologic process should show x-ray evidence other than adhesions, and if the roentgen examiner finds little or nothing else, he lays

himself open to the criticism either of lacking thoroughness or of avoiding a specific diagnosis. Cases in which a laparotomy has been done previously, often show adhesions—so often that their roentgenologic discovery is not edifying to the surgeon.

Peristalsis.—There is a lack of definite knowledge as to the normal peristalsis of the colon other than a general agreement that forward movements *en masse* occur at infrequent intervals, also little is known regarding peristalsis in disease. Jordan has seen increased speed of the massive movement and a greater distance traversed in diarrhea and with the enema. Case[12] noted "exaggeration of normal antiperistalsis" in carcinoma. Schwarz has observed stenotic hyperperistalsis with carcinomatous stricture at the hepatic flexure.

Length and Diameter.—Increased length of the colon, the redundancy being usually most marked in the sigmoid and transverse portions, is a relatively common finding in constipated persons. Such redundancies are also found, however, in colons which functionate normally. Since the longitudinal muscle-fibers are largely collected into the tenia, it is obvious that the tone condition of the tenia has much to do with the length and position of the colon at a given moment. Considered in this way, it may be that so-called redundancy is often merely an expression of atony. Redundancy of the sigmoid with dilatation (megasigmoid) has been observed occasionally. In congenital idiopathic dilatation of the colon (Hirschsprung's disease) the immense dilatation throughout is strikingly shown by the x-ray. Dilatation of the cecum, ascending and transverse portions, with evident loss of tone, is not infrequently noted. Dilatation of any part of the colon, proximal to a stenosis, may be evident. Hypertonic or spastic narrowing of the colon, particularly in its transverse, descending and sigmoid portions, is noted occasionally in cases of constipation, but it may accompany a colitis with frequent stools. A narrow unhaustrated colon is often seen in cases of granular or ulcerative colitis.

Motility.—Hypermotility of the colon is seen typically in

association with non-obstructing gastric carcinoma, in which condition the head of the meal may be in the descending colon or even the ampulla in six hours. Hypermotility with similar but usually less marked advancement is also seen in duodenal ulcer, achylia and diarrheic conditions. Hypomotility with decidedly slow progress of the meal through the colon, may be due either to organic obstruction or merely to functional impairment. Retention of all or the greater part of the meal in the colon after forty-eight hours may be regarded as possibly significant of obstruction or grave functional disturbance, but further conclusions should not be drawn from this fact alone.

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CHAPTER XXIII

CANCER OF THE COLON

Precisely as in cancer of the stomach, the most important sign of cancer of the colon is the filling-defect—a local irregularity of contour produced by jutting of the growth into the intestinal lumen, by contracture of the infiltrated wall, and probably to some extent by spasm produced by the neoplasm. The irregularity may be rather sharply delineated, but is more often indefinitely shaded.

Next in importance to the filling-defect is the presence of obstruction, the fact of which is alone highly significant, since non-malignant stricture of the colon is exceedingly rare (Hurst).[1] The blocking may be evidenced by an accumulation and delay of the meal proximal to the stenosis, and by obstruction to the enema. It is noteworthy that the inflow of the enema is sometimes markedly or completely obstructed, when the passage of the meal is apparently hindered only slightly or not at all, and the patient gives no history of obstipation. This is probably due to a valve-like effect of the growth. Dilatation of the bowel above the stricture is sometimes noted. To these signs may be added the coincidence of a palpable tumor with the filling-defect or with the point of obstruction. In a few reported instances an exaggeration of peristaltic activity was noted proximal to the obstruction. Extension of the growth outside the bowel may occasionally result in evident fixation, but more often the normal mobility of the intestine is not impaired.

For eliciting signs of carcinoma, the combined screen and plate examination with the opaque enema is usually more convenient and effective than examination with the opaque meal.

By the enema the entire bowel or that portion distal to a complete obstruction is visualized throughout at a single examination; filling-defects are more readily discovered, and the site of the obstruction is quickly determined. Where the latter is extreme, its proximal limits may be found by giving an opaque meal.

A filling-defect due to carcinoma is characterized by its irregularity, its constancy upon all plates and at successive examinations, its permanence in spite of palpatory manipulation, and its persistence after the administration of antispasmodics. Its size will depend, of course, upon the extent of the growth, but in those patients whose symptoms are at all suspicious, the lesion will nearly always be found of demonstrable proportions.

The filling-defect may show as a concentric local narrowing of the lumen (napkin-ring carcinoma) or it may be unilateral. In some cases with marked obstruction the enema may terminate with a bluntly rounded, smooth contour at the site of the stenosis, while in others more or less tailing out may be seen.

The filling-defect of carcinoma is imitated by a variety of conditions. Among these are:

1. Gas.
2. Insufficient quantity of the enema.
3. Fecal matter.
4. Spasm.
5. Extrinsic tumors.
6. Pressure of bony parts.
7. Adhesions.
8. Diverticulitis, tuberculosis and other lesions of the intestine.

Gas collections in the colon are relatively common and they sometimes produce filling-defects simulating those of an organic lesion. When gas accumulations are present they will usually be found in the proximal portion of the bowel, most often in the hepatic flexure, ascending colon or cecum. They can sometimes be displaced by palpation during the screen-examination,

they may have a varying configuration upon successive plates and, as a rule, the outline of the bowel can be distinguished (Fig. 502).

By failure to give a sufficient quantity of the enema the bowel may not be filled throughout, showing patches here and there resembling filling-defects. The patches tend to shift about and are not very deceptive. By lack of thorough purgation and

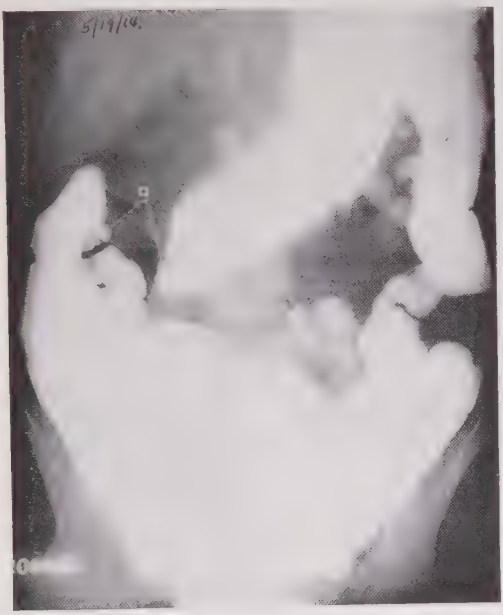

FIG. 502.—Gas in the colon near hepatic flexure; G, imitating the filling-defect of cancer.

cleansing, fecal matter may be left in the bowel and cause filling-defects. However, with the routine preparation previously described, this rarely occurs.

Localized spasm of the colon may produce most vexing imitations of true filling-defects. Usually the affected segment is narrowed and shows fine, irregular haustra. Rarely, the spasm may completely obstruct the enema at the point involved. Figures 503 and 504 illustrate marked spasm of the transverse colon, a duodenal ulcer being found at operation. The sigmoid or descending colon, occasionally the transverse,

FIG. 503.—Obstruction of the transverse colon at *O*, by spasm. No corresponding palpable mass. See Fig. 504.

FIG. 504.—Same case as in Fig. 503. Colon patent after belladonna had been given. At operation a duodenal ulcer was found; colon negative. No roentgen examination of the stomach and duodenum was made in this case.

is sometimes intensely spastic and narrow, and, though filled with the enema, shows small, irregular haustration (Fig. 505). In all cases where spasm is suspected, the patient should be given belladonna to physiologic effect and the examination repeated.

Extrinsic tumors by the thrust of their outline into the contour of the colon may rarely produce apparent filling-defects, especially in fixed portions of the bowel. As a rule, however,

FIG. 505.—Marked spasticity of pelvic colon, S.

such tumors do not alter the outline of the colon and their extrinsic situation is evident upon screen-examination.

Pressure of the transverse colon against the spine may cause a seeming defect at this point, and a small apparent defect is often seen in the sigmoid flexure where it rises over the brim of the true pelvis, but such defects will hardly be taken seriously.

Adhesions, when present, are usually about the cecum or pelvic colon. They may, but rather exceptionally, cause sharp irregular serration of the intestinal border, with more or less fixation, and occasionally may obstruct the bowel.

Diverticulitis of the sigmoid, or other parts of the colon, by reason of the accompanying inflammatory thickening, may produce obstruction and filling-defects resembling those of cancer. When the characteristic extra-luminal, barium-filled diverticula can be discerned, the diagnosis is apparent, but sometimes the sacculations are not clearly seen as such and roentgenologic distinction from cancer is impossible.

Filling-defects with or without a palpable tumor or obstruction, involving the cecum and ascending colon, should not be too hastily interpreted as cancer, since these signs may be produced by tuberculosis, which is a rather frequent lesion in this part of the colon. Purely roentgenologic differentiation of the two conditions cannot be made, but the clinical features may be decisive.

An extensive appendiceal abscess may distort the cecum and ascending colon and be felt as a mass. Here the elementary clinical facts should at least put the examiner on his guard.

Other lesions may also produce filling-defects or obstruction, or a palpable tumor, and thus show a roentgenologic similarity to cancer. Included among these are various benign tumors, polypi, syphilis, actinomycosis, and cicatricial stricture from ulcer. These lesions are all relatively infrequent. Their differentiation from cancer of the bowel would require careful weighing of all the facts, both clinical and roentgenologic.

ILLUSTRATIVE CASES

Case 86,304, female aged 53 years. For thirty years she has had hemorrhages from the bowel intermittently. These have been less frequent during the past two years. A year ago she had a dysentery with very frequent stools which at times showed bright red blood. Since then she has had diarrhea, off and on. During the past few months she has had pain under the left costal margin in the axillary line. Her bowels are always loose, with much gas and distress. Weight loss, 45 pounds in one year. Marked prolapse of anus and internal hemorrhoids. Hemoglobin 65. Wassermann negative. Roentgen findings: Annular filling-defect, with extreme narrowing of lumen in descending colon near splenic flexure (Fig. 506). Notwithstanding the great local narrowing, the entire bowel filled readily with

FIG. 506.—Case 86,304. Napkin-ring carcinoma of colon. Filling-defect and narrowing, F. D. Photograph of specimen Fig. 507.

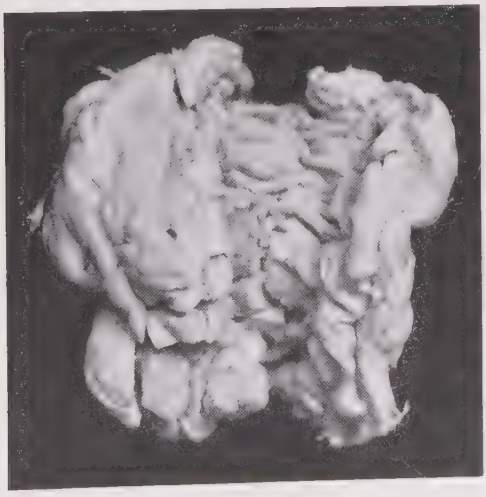

FIG. 507.—Case 86,304. Photograph of specimen.

the enema and without complaint on the part of the patient. Findings at operation: Napkin-ring carcinoma, splenic flexure of colon, deeply situated and very adherent. Some glandular involvement. Operation: Exsection (Mikulicz). Pathologist's report: Carcinoma (Photograph of specimen, Fig. 507).

Case 130,337, female, aged 40 years. Chronic diarrhea for six years, with four to six watery stools daily, and cramping abdominal pain. With this there has been a slowly progressive weakness. Weight loss, 12 pounds. Nodular, tender mass, right abdomen, below costal margin. Free fluid in abdomen; ankles swollen. Hemoglobin 30. Stools show Endameba histolytica. Roentgen findings: Gross filling-

Fig. 508.— Case 130,337. Carcinoma of the right half of the transverse colon. Filling-defect, F. D.

defect, transverse colon, near hepatic flexure, corresponding to a palpable mass (Fig. 508). Findings at operation: Large carcinomatous tumor of hepatic flexure, 7 or 8 cm. in diameter. Second tumor, middle of transverse colon, adherent to gall-bladder. Ileum adherent to tumor. Operation: (1) Resection cecum, ascending colon, hepatic flexure and three-fifths of transverse colon. Murphy button anastomosis, end to side. Cholecystectomy. Pathologist's report: (1) Tumor of hepatic flexure, carcinoma. (2) Small tumor of transverse, inflammatory. (3) No glandular involvement. (4) Catarrhal cholecystitis.

Case 157,410, male, aged 31 years. Since an attack of grippe more than two years ago he has not been entirely well. About a year ago he noticed jaundice, itching of skin and progressive weakness. Five months ago he had a chill, high fever, severe pain in lower abdomen, nausea and vomiting. He was in a hospital for three weeks, and was told that he had "peritonitis caused by rupture of the intestine." After leaving the hospital he gained in weight on a selected diet, but had a continuous dull ache and occasional sharp pain in the lower abdomen. Bowels regular, with cathartics. In the past month he has had more abdominal soreness and has grown weaker. He thinks that he may have passed very small amounts of dark blood in the stools. Weight loss, 22 pounds in five months. Firm, irregular tumor in cecal region. Lower abdomen tense and distended. Probably some ascites. Rectal shelf apparently free. Hemoglobin 35. Roentgen-ray of chest negative. No local reaction to tuberculin subcutaneously. Roentgen findings: Annular filling-defect of ascending colon corresponding to palpable mass (Fig. 509). Findings at exploration: Large tumor of cecum and ascending colon, adherent over large surface of parietal peritoneum. Nodules extending into peritoneum and mesentery. Specimen excised for microscopic examination. Radical operation not indicated on account of extent. Pathologist's report: Adenocarcinoma.

Case 146,918, male, aged 54 years. Ten weeks ago he began to have diarrhea with four or five stools daily and colicky pain. The pain has subsided but he still has tenderness in the left lower abdomen. For a week he has been using saline enemata daily and the diarrhea has lessened, but there is still tenesmus and frequent desire to stool, with scant results. He has passed blood several times after stooling during the past two weeks. No weight loss. Hemoglobin 88. Tender movable mass, size of an egg, in left abdomen at level of iliac crest. Complete fistula in ano. Roentgen findings: The roentgenogram shows two filling-defects; one low in the descending colon, the other in the sigmoid (Fig. 510). Findings at operation: Double carcinoma; one of napkin-ring type in descending colon; the other in the sigmoid. Operation: Mikulicz. Pathologist's report: Carcinoma.

Case 107,182, female, aged 44 years. Notwithstanding a good appetite and maintenance of weight the patient has not been well for a year, complaining chiefly of nervousness and insomnia. A month ago she began to have attacks of epigastric pain becoming general over the abdomen, followed by a loose watery stool and relief. She may have two or three of these attacks daily; no relation to meals. To-day, for the first time she noticed a few streaks of bright blood in the stool. Until a month ago she was always constipated; now has two passages

FIG. 509.—Case 157,410. Filling-defect, ascending colon, F. D. Annular carcinoma Appendix visible, A.

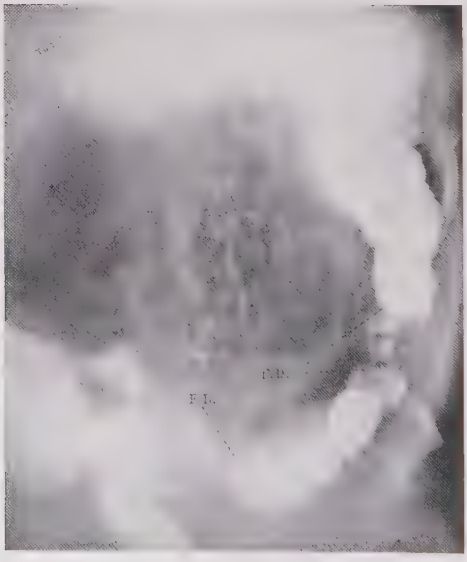

FIG. 510.—Case 146,918. Filling-defect low in the descending colon, also in the sigmoid, F. D.

FIG. 511.—Case 107,182. Filling-defectof cecum, F. D. Carcinoma.

FIG. 512.—Case 144,665. Filling-defect of cancer, F. D.

FIG. 513.—Case 80,026. Obstruction to enema at O.

FIG. 514.—Case 80,026. Roentgenogram after ingested meal. Filling-defect, F. D.

daily. At an examination two weeks ago, elsewhere, a mass was found in the right abdomen. Weight loss, 18 pounds in one and a half years. Hemoglobin 60. Tumor in cecal region, 4 or 5 cm. in diameter, rather fixed. Roentgen findings: Filling-defect of cecum

FIG. 515.

FIG. 516.

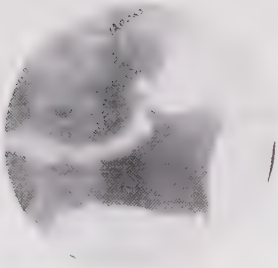

FIG. 517.

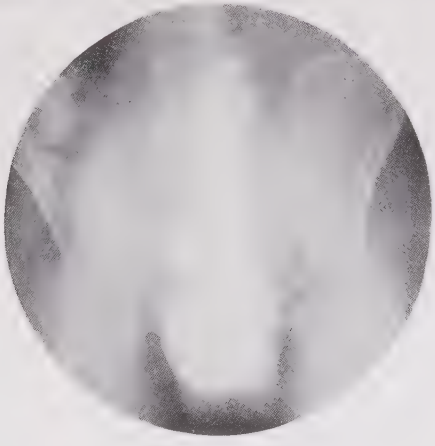

FIG. 518.

FIGS. 515, 516, 517, 518.—Cancer of colon, producing either obstruction, O, or a filling-defect, F. D., or both.

corresponding to a palpable mass (Fig. 511). Findings at operation: Carcinoma of ileocecal coil and ascending colon. Large tumors in mesentery of small intestine along spine. Free fluid. Liver not involved. Operation: Ileocolostomy.

Case 144,665, female, aged 44 years. Up to ten months ago she was

in general good health, but since then she has had no appetite and has a little discomfort from gas three or four hours after meals. During the past two or three months her bowels have been loose, with three or

Fig. 519.

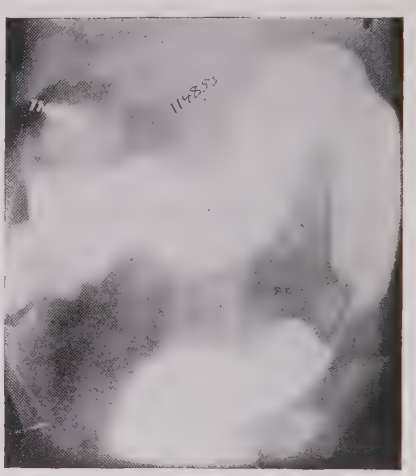

Fig. 520.

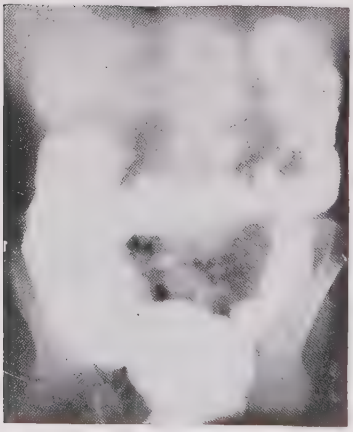

Fig. 521.

Fig. 522.

Figs. 519, 520, 521, 522.—Cancer of colon, some showing only obstruction, O, others a filling-defect F. D.

four stools daily, and these have occasionally shown small clots of dark blood. She has an indefinite ache in the lower abdomen which she thinks is of ovarian origin. General strength poor. Weight loss, 15 pounds in nine months. Hemoglobin 35. Wassermann negative.

Abdomen hard and resistant throughout, especially lower right, where an irregular hard mass can be felt. Pelvis negative save for small cervical polyp. Roentgen findings: Annular filling-defect with marked narrowing of lumen in right half of transverse colon, with palpable

Fig. 523.

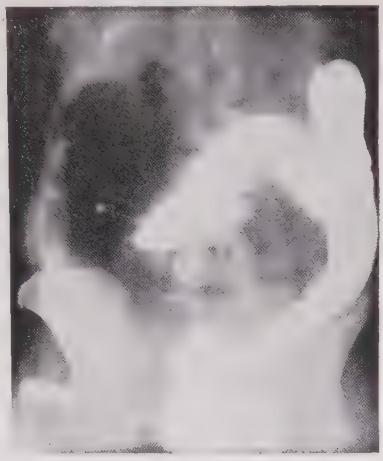

Fig. 524.

Fig. 525.

Fig. 526.

Figs. 523, 524, 525, 526.—Cancer of colon. O, obstruction. F. D., filling-defect.

tumor (Fig. 512). No roentgen examination of stomach requested. Findings at exploration: Tumor 6 or 7 cm. in diameter, in transverse colon, involving and penetrating posterior wall of stomach. Glands and omentum involved and adherent to abdominal wall. Tumor in liver. Lumen of bowel permits invagination of finger past tumor.

Case 80,026, male, aged 37 years. Five months ago he suddenly developed diarrhea with griping pain. The stools, which were four or five in number daily, contained mucus, but no blood. The diarrhea ceased after two months and was followed by constipation which has

Fig 527.

Fig. 528.

Fig. 529.

Fig. 530.

Figs. 527, 528, 529, 530.—Cancer of colon. O, obstruction. F. D., filling-defect. Photograph of specimen in corner of roentgenogram.

continued since. He is obliged to take cathartics and has gone for a week without stooling. When the bowel does not move he has general abdominal soreness. Normal weight 165; present weight 135. Definite thickening felt in left iliac fossa. Proctoscopic examination

negative. Cystoscopy shows edema of bladder-wall and bladder seems dragged upward. Roentgen findings: Marked obstruction to enema low in colon (Fig. 513). The ingested meal shows a filling-

Fig. 531.—Carcinoma at juncture of cecum with ascending colon and intussusception of the ileum into the cecum.

Fig. 532.—Carcinoma of right half of transverse colon.

defect throughout a considerable extent of the descending colon and sigmoid (Fig. 514). Findings at exploration: Tumor of sigmoid, probably malignant. The growth is about 17 cm. long, and is fixed

to the bladder and to the pelvis in the vicinity of the left ureter. Inoperable.

FIG. 533.—Carcinoma of the cecum.

FIG. 534.—Carcinoma of the cecum.

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CHAPTER XXIV

DIVERTICULITIS

According to McGrath,[1] Graser[2] in 1899 was the first to demonstrate the association of acquired diverticula with "isolated, circumscribed adhesive peritonitis" on the colon, the latter condition having been mentioned by Virchow in 1853. Although not of common occurrence as compared with other lesions of the large bowel, diverticulitis is met with sufficiently often to require its consideration in many cases with symptoms referable to the colon. Thus as early as 1907, Mayo, Wilson and Giffin[3] were able to report 5 cases operated on in the Mayo Clinic and in 1912 Giffin[4] collected 27 such cases, in 17 of which there was involvement of the sigmoid.

Diverticula, here as elsewhere, may be divided into two classes: The congenital and the acquired. With the congenital class we are not here concerned. The acquired diverticula are divided into two classes: the true or complete and the false or incomplete. The true diverticula are practically never seen in the colon. McGrath,[1] in a very complete review of the pathology, states that nearly all these diverticula are of the "false" or incomplete type; that is to say, they are "herniæ of the mucosa" through the muscularis, commonly at points where the latter is penetrated by blood-vessels. They are found in all parts of the colon, the number of diverticula present varying all the way from 1 to 300 or 400. In this clinic the sigmoid and descending colon have been the divisions most frequently involved. The chief causes are weakness of the muscularis with an increase of intra-intestinal pressure, such as occurs in stasis and gas formation. Diverticula vary in size from 2 mm. to 5 cm. or more. They are usually round or ovoid, and most often sessile, though occasionally pedunculated. The opening

into the bowel may be narrow and practically stenosed, or it may be almost as wide as the diverticular cavity. The sacs usually contain fecal matter and sometimes fecaliths. Histologically, the sac-wall is made up of mucosa, submucosa and serosa, the muscularis being slight or wanting. The mucosa may be slightly atrophic or even ulcerated, but the most constant pathologic process is the chronic, proliferative extramucosal inflammation, the "peridiverticulitis" of Wilson, with round-cell infiltration, which results in mass formation.

Prominent features of the symptomatology, as described by Giffin, are the following: The proportion of males to females appears to be 2 or 3 to 1. An inclination to obesity is noted almost without exception; the patients are of sound flesh with good color, and where loss of weight occurs, it is only slight. Abdominal pain, usually of considerable severity, is the rule. Often the patient is able to localize the pain to the sigmoid or descending colon. Constipation is complained of by the majority and is often of more than moderate severity. Vesical symptoms, such as urinary frequency and tenesmus, are occasionally noted. In every instance of diverticulitis of the sigmoid, a mass was felt in the left lower quadrant or in the pelvis. The proctoscopic examination is likely to be negative unless the tumor has intussuscepted into the rectum. Absence of blood from the stools is notable and this is explained by the fact pointed out by Wilson[3] that the inflammatory process is primarily extramucosal, and the condition is really a peridiverticulitis.

In the presence of these symptoms the differential diagnosis becomes a matter of importance. One condition which must be eliminated is that of left-sided appendicitis. Here the roentgenologic examination would be decisive by showing the position of the cecum. The most difficult differentiation is from carcinoma. While the symptoms are not typical of carcinoma, they do not absolutely exclude it, unless spasm and extraluminal shadows are present during the x-ray examination. In some cases, however, this differentiation can hardly be made roentgenologically, for Wilson[5] has shown that carcinoma may develop

on diverticulitis. Furthermore, this differentiation is rendered difficult by such complications as perforation, abscess formation, obstruction, fistulæ, peritonitis, adhesions, etc.

The question arises as to what can be expected from the x-ray. In 1914, Abbe[6] reported a case of sigmoid diverticulitis in which a roentgenologic examination had been made by Le Wald. A bismuth enema showed only a narrowing of the

Fig. 535.—Case 99,640. Roentgenogram of barium-filled colon (enema), showing marked filling-defect in sigmoid with extraluminal shadows (diverticula) D.

sigmoid. Later a bismuth meal was given and radiographs taken up to the tenth day showed the constant presence of small round spots in the vicinity of the sigmoid, long after both enema and meal had been evacuated. The shadows admitted of but one explanation, namely, bismuth fluid retained in the diverticula. My experience with the cases hereinafter described indicates that, in some instances at least, the roentgen signs of diverticulitis are more or less characteristic. The cases are as follows:

Case 99,640, male, aged 55. Examined January 26, 1914. Family and personal history negative. Gall-stones (passed one); severe cholecystitis and peritonitis fifteen years ago. Twelve years ago he was operated on for left inguinal hernia and hemorrhoids. Clinical

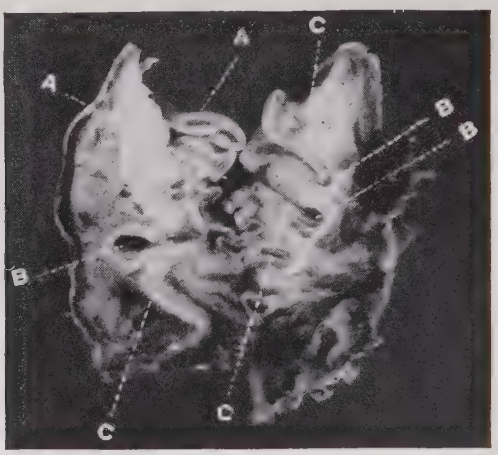

Fig. 536.—Case 99,640. Longitudinal section through sigmoid, showing multiple diverticula with marked thickening of intestinal wall and narrowing of lumen. A, mucosa; B, diverticula, containing fecaliths; C, canal leading to diverticular sac.

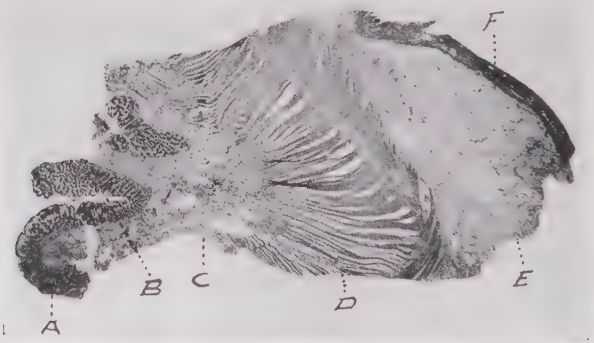

Fig. 537.—Cross section of wall of normal sigmoid, photomicrograph, magnified four times, showing normal mucosal fold. Note that this fold does not penetrate the musculature. A, mucosa. B, mucosal fold. C, submucosa. D, musculature. E, subperitoneal fat. F, peritoneum.

history: Post-operative abscess followed previous operation with symptoms of cystitis. The abscess developed around the ligature later, which was passed by urethra. Since then the patient has had symptoms of bowel obstruction, the last time in December, 1913, one attack

five years prior to this. There were left-sided griping and gas pains with much distention. At one time the bowels did not move for eight days; ordinarily, however, they moved regularly. Apparent lump and soreness in left iliac fossa with pressure affecting the bladder.

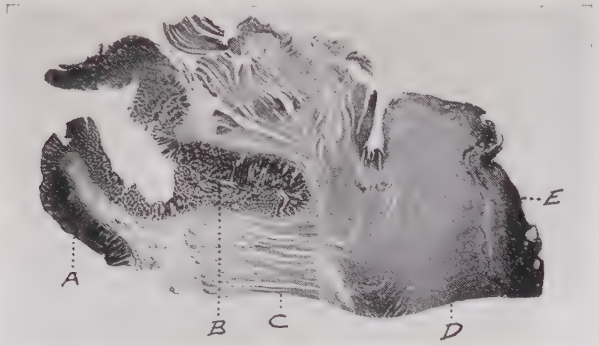

FIG. 538.—Cross section of wall of sigmoid, photomicrograph, magnified four times. Shows mucosal fold and submucosa separating the circular muscular fibers and penetrating to the longitudinal musculature. An early diverticulum of this type can hardly be demonstrated radiologically because of the absence of flask-like dilatation. A, mucosa. B, diverticulum. C, circular muscle fibers. D, subperitoneal fat. E, peritoneum.

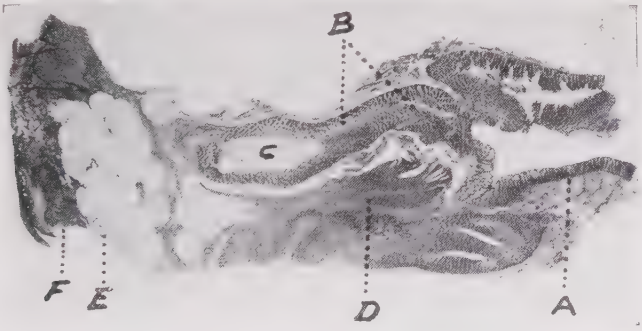

FIG. 539.—Cross section of wall of sigmoid, photomicrograph, magnified four times. Deep-seated, late stage diverticulum with flask-like ampulla. The diverticulum has separated the circular fibers which are here seen compressing the neck, passed through the longitudinal bands of muscle and penetrated into the subperitoneal fat. This advanced type offers the greatest opportunity of radiologic demonstration because of its capacity and the distance from the intestinal lumen. A, mucosa of bowel. B, canal leading into diverticular cavity at C. D, musculature. E, subperitoneal fat. F, thickened peritoneum.

Pencil stools before last attack. The patient returned to his home, and prior to his operation, March 17, 1914, suffered several obstructive attacks, with flatulence, rumbling and stinging pain over the pubis and left side during bowel movement. Sensation of "something pushing

up from rectum" when in sitting posture. Some weight fluctuation but the greatest loss at any one time was 12 pounds. Urine negative. Roentgen examination: January 27, 1914, patient was examined in the routine way by barium enema. Roentgenograms showed an irregular filling-defect with marked narrowing in the sigmoid. Small barium shadows were observed outside the lumen of the bowel, an appearance quite unusual, and at that time inexplicable (Fig. 535). From the clinical facts and the roentgen appearance, W. J. Mayo suggested to the patient that the condition might be diverticulitis. Findings at operation (March 17, 1914): Diverticulitis of the sigmoid. Bowel exceedingly thick and adherent to pelvic wall posteriorly; about 35 cm. of bowel involved. Operation: Mikulicz. Pathologist's report: Tissue removed, sigmoid. Diagnosis: Diverticulitis (Fig. 536).

FIG. 540.—Case 105,595. Barium-filled colon (by enema) with extraluminal shadows (diverticula) at A.

Case 105,595, male, aged 51. Examined May 7, 1914. Family and personal history negative. Denies any previous disease. Appendectomy elsewhere, without any exploration. Clinical history: For ten years he has been constipated. In the past two years he has noticed a sore lump in the left lower abdomen which has been associated with an increase of constipation. On two occasions this lump

became swollen and very tender. In December, 1913, he had a chill with fever, and griping pain with gas, marked swelling and soreness at the spot complained of. Recent similar attack four days ago. Stools small and tapered, necessitating laxatives, but no blood or pus noted. When the lump is swollen, the patient urinates frequently with some pain. General health good. Weight loss, 5 pounds. Physical examination: Tenderness and resistance in lower left abdomen. Rounded elongated mass felt in bimanual examination. Rectum seems negative aside from small hemorrhoids. Proctoscopic examination: Negative. Roentgen findings: Negative save for slight enlargement of cecum. At the same time small shadows were noted outside

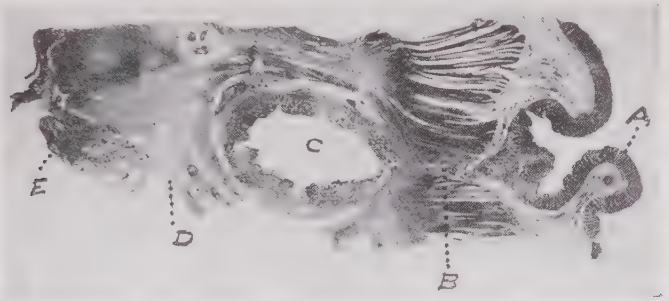

FIG. 541.—Case 105,595. Cross section of diverticulum, photomicrograph, magnified four times. A, mucosa of sigmoid. B, neck of diverticulum (not well shown on account of depth at which section was cut), extending from lumen of sigmoid through circular muscular fibers to diverticular sac at C. D, subperitoneal tissue. E, peritoneum.

Note that mucosal lining of the diverticulum is like that of the sigmoid, and it differs in this respect from the inflammatory pockets produced by perforated ulcer of the stomach which are often, but wrongly, spoken of as diverticula.

the sigmoid lumen, but their significance was not at that time appreciated (Fig. 540). Findings at operation: Diverticulitis of sigmoid. Operation: Mikulicz. Pathologist's report: Tissue removed, sigmoid. Diagnosis: Diverticulitis (Fig. 541).

Case 107,983, male, aged 49 years. Examined June 12, 1914. Previous history unimportant. Catarrhal jaundice four years ago, with epigastric pain. He denies lues or gonorrhea. Clinical history: Present trouble began six weeks ago with gas in the lower bowel and sharp, shooting pain in the left lower abdomen, passing to the hypogastrium, intermittent in character and relieved spontaneously or by flatus. Attacks come only if he gets a "cold," and last four or five days; he has had three or four seizures in all. During the intervals there is some discomfort from gas, which, although there are no distinct vesical symptoms, "interferes somewhat with the bladder."

He has lost some weight on diet. He has been constipated and used laxatives for years. He has had occasional tenderness in the region complained of during the past six weeks. Physical examination: Mass in the sigmoid area, not now tender. Prostate slightly enlarged, otherwise negative. Small hemorrhoids. Roentgen findings (after opaque enema): Filling-defect in upper sigmoid. Marked spasticity of transverse, descending colon and sigmoid (Fig. 542). A reray after the administration of belladonna, was suggested but could not be obtained. This request was made because of the great amount of

FIG. 542.—Case 107,983. Filling-defect of sigmoid with extraluminal shadows—barium-filled diverticula—at A.

spasm noted, which had to be considered as a possible cause of the sigmoid deformity, although a lesion was strongly suspected. In the absence of a reray no attempt was made to carry the diagnosis further. Operation: A tumor of the sigmoid about 25 cm. in length, extensively adherent to the lateral wall of the pelvis in the vicinity of the common iliac vein was removed (Mikulicz operation). Pathologist's report: Diverticulitis.

Case 109,311, man, aged 54 years. Operation two years ago elsewhere; gastro-enterostomy for duodenal ulcer and excision of small growth from the ileum, microscopically cancer. He was completely

relieved until two weeks ago when, following indiscretion in diet, he had cramping pain in the left iliac fossa, becoming generalized over the abdomen. The pain lasted about three days, and the patient has gradually grown better, though his appetite is poor, and there is some loss of weight and strength. Constipation; some mucus in stools. During the past two days he has had burning with micturition and nocturia which he never had before. Weight loss, 10 pounds. Oblong, firm, movable mass in left pelvis felt on bimanual examination. Hemoglobin 86. Roentgen findings: Irregular obstruction of sigmoid (Fig. 543). Findings at operation: Carcinoma lower sigmoid, 25 cm.

Fig. 543.—Case 109,311. Obstruction at O.

above rectum, involving 10 cm. of sigmoid. Obstructing tumor, probably developing on diverticula. Adhesions to bladder and left ureter. Operation: Mikulicz. Pathologist's report: (1) Diverticulitis. (2) Carcinoma on diverticulitis.

Case 147,966, man, aged 52 years. One year ago he had a brief attack of slight pain and soreness in left iliac fossa. Three weeks ago he had cramps in the lower abdomen, followed by a little fever and some soreness in the left iliac fossa. By taking Russian oil he has fairly soft movements, but these are accompanied by pain in the left lower quadrant and some cramping in the rectum. He is afraid to eat solid food because of the increased pain when heavy fecal matter reached

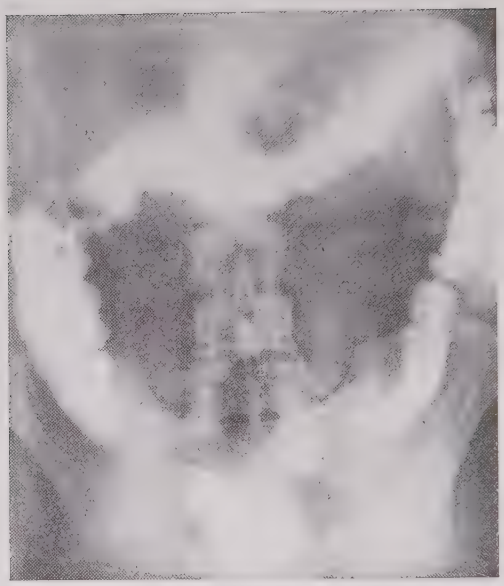

FIG. 544.—Case 147,966. Involved area at D.

FIG. 545.—Case 143,262. Obstruction at O.

the sore area. He noticed a little irritation of the bladder when the present attack began. Underweight 20 pounds. Tenderness and sense of mass low in left quadrant. Roentgen findings: Diverticulitis of sigmoid (Fig. 544). Findings at operation: Tumor of the sigmoid just at the pelvic brim, about 10 cm. in length, closely attached to the pelvic wall, with an abscess in the mesentery containing thick pus. Pathologist's report: Diverticulitis.

Case 143,262, man, aged 35 years. Two years ago he had slight pain in the left abdomen radiating across navel. Recovery in two days. Since then he has been well until sixty days ago. At that time he was abroad and suffered a severe attack, lasting four weeks. The attack was accompanied by fever, and a very small amount of blood was noticed in the stool at one time. His physician could feel a tumor about 10 cm. in diameter in the left lower quadrant, and made a diagnosis of diverticulitis of the sigmoid. This seemed to be confirmed by bismuth plates of the bowel. Under treatment with castor oil and diet the swelling diminished and since returning to this country, he has felt fairly well, save for some "weakness" in the left side. His bowels are constipated. Micturition usually normal, but there was some pain with urination during his attack. Weight loss, 5 pounds. Area of resistance in left lower quadrant; question of a mass. Roentgen findings: Obstruction of the sigmoid, with marked spasticity above and below the point of obstruction (Fig. 545). Findings at operation: Tumor of the sigmoid—diverticulitis? carcinoma?—perforated and adherent to parietal peritoneum at brim of pelvis. Tumor mass about 12 cm. long, loosened with difficulty. Operation: Mikulicz. Pathologist's report: No diverticulitis or carcinoma found. (The specimens examined had become necrotic. C. H. Mayo considered the case one of diverticulitis.)

The outstanding roentgenologic feature of the above cases is the demonstration in some of them of oval or rounded shadows projecting from or lying outside the intestinal lumen, and representing the barium-filled diverticula. Such shadows in conjunction with spasm, narrowing and defective filling of the bowel would seem pathognomonic of diverticulitis. While a carcinoma might show more or less apparent pocketing, the pockets are not likely to have the rounded symmetry of diverticula. In the instance of carcinoma supervening upon diverticulitis, if rounded extralumenal shadows were present, the lesion could not be distinguished from a benign diverticulitis, while if these

shadows were not present the case would probably be regarded simply as one of carcinoma.

The possibility should be borne in mind that by reason of a stenotic inlet, or the extremely small size of the diverticula, or because they contain fecal matter, they may fail to fill with the clysma. In this event there is seen only a filling or obstruction defect proportioned to the extent of inflammatory thickening and not distinguishable roentgenologically from that of carcinoma.

Fig. 546.—At operation a diverticulitis was found in the sigmoid. A careful examination of the transverse colon failed to discover any diverticula in this part of the bowel. The extraluminal shadows at B are probably due to barium in contracted haustra.

As to the chance of a fecalith being seen, that would depend upon its size, density and situation. It is also quite possible that sufficient barium may enter a diverticulum containing a fecalith to make the sac visible.

Diverticular shadows may be imitated by phleboliths, calcified glands, renal and ureteral calculi, and occasionally by barium pent up in contracted haustra. By manipulation during the screen-examination or making plates at different angles it may

be possible to show that shadows of the concretions mentioned have no relation to the bowel. Plates made before giving the enema or meal would be decisive.

Fig. 547.

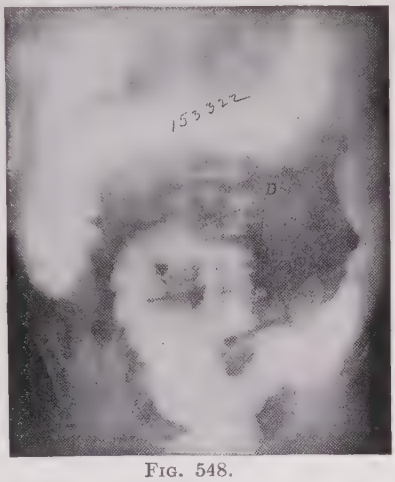

Fig. 548.

Fig. 549.

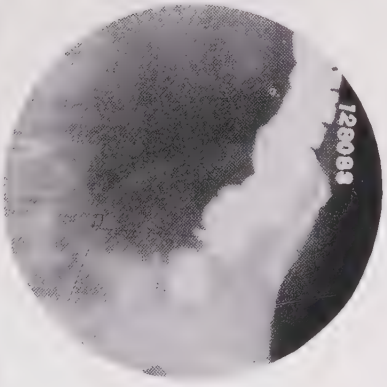

Fig. 550.

Figs 547, 548, 549, 550.—Diverticulitis of pelvic colon. Involved area at D.

Haustral shadows sometimes resemble those of diverticula, as shown in Fig. 546, where they appear to be detached from the lumen of the bowel. Some differential points are:

1. Haustral shadows are not accompanied by a filling-defect

in that portion of the bowel, while diverticular shadows may be thus accompanied.

Fig. 551.—Diverticulitis of the sigmoid with stricture.

Fig. 552.—Multiple diverticula of the colon. The round white areas are the barium-filled diverticula.

2. Haustral shadows tend to disappear or change their situation. The change may not be rapid and the screen examination

should be sufficiently prolonged or plates should be made at intervals long enough to permit this change of situation. Diverticular shadows maintain a fixed position, and may persist after the bowel is emptied or partially emptied. For this reason, an examination after evacuation of the colon may strengthen the diagnosis.

Fig. 553.—Diverticulitis of the sigmoid. Note "spasm" of the sigmoid which is commonly seen in diverticulitis.

Although Le Wald's case indicates otherwise, the liquid opaque clysma introduced under some pressure, after purgation and a cleansing enema, is probably more efficient than the meal in demonstrating surgical diverticulitis and is more convenient. Portions of the meal tend to scatter in small masses and these may be confounded with diverticula. However, there can be no objection to using both meal and enema.

Since the shadows of diverticula may be overlapped by the barium in the bowel at certain angles of view, the examination should be made with the patient in various positions. Stereoscopic plates may sometimes give additional assistance.

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Fig. 554.—Diverticulitis of the descending colon and sigmoid. Note the spasm and (extralumenal shadows) diverticula.

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CHAPTER XXV

TUBERCULOSIS OF THE INTESTINE

The early symptoms of ulcerative tuberculous colitis are not sufficiently characteristic to make possible a definite clinical diagnosis, even in the presence of pulmonary tuberculosis. If any benefit is to come from treatment it is imperative that the disease be recognized early, and for this recognition the roentgen-ray furnishes the most certain means as yet available. A positive and independent roentgen diagnosis of tuberculous colitis is difficult, however, for there are no pathognomonic roentgen signs, as the filling-defect and the absence of the normal barium shadow in the cecocolon are signs of any ulcerative lesion. Even the finding of *Bacillus tuberculosis* in the stool is of no value in determining the nature of the lesion in the intestine unless a tuberculous lesion in the lungs or *Bacillus tuberculosis* in the sputum can be excluded. Every patient with indefinite abdominal complaint should, therefore, have a complete roentgenologic and general clinical examination. Tuberculosis has such a predilection for the ileocecal coil that a lesion in this part of the intestine, especially if associated with pulmonary tuberculosis, is most likely tuberculous. Distal segments of the colon are seldom invaded; the disease almost always involves the proximal portion, especially the small bowel, ileocecal valve, cecum, appendix, and ascending colon (Brunner).[1] Necropsies have demonstrated that from 70 to 90 per cent of persons suffering with advanced pulmonary tuberculosis have tuberculosis of the intestine.

In reviewing the physiology of the colon, the following facts should be kept in mind for a better understanding of the abnormal colon. The cecum and ascending colon form a pouch-like expansion of the proximal part of the large bowel. Their walls are thinnest and therefore weakest, and capable of great

distention. The interior depressions of the cecum correspond with the surface haustra. It is definitely known that food remains in this portion of the colon longer than in any other, and it is thought that this delay is largely due to haustration and antiperistalsis. With these physiologic functions in mind, it is not difficult to understand how their loss by disease explains the emptiness and gap in the physiologic barium shadow seen in ulcerative diseases of the colon. The bowel contents pass with abnormal rapidity, because the normal functions which retard the physiologic progress are absent."

The pathology of tuberculosis of the intestine may conveniently be divided into three types:

1. Nodular.
2. Ulcerative.
3. Fibrous.

In the nodular type the lesion is made up of conglomerate tubercles which are principally extraluminal in their earliest stages. The nodules are not infrequently seen alone, apparently unaccompanied by tuberculosis elsewhere; they may rarely be seen in association with chronic ulcerative tuberculous ileocolitis, and in such case may be the sequel of pulmonary tuberculosis. This type can hardly be recognized roentgenologically unless it produces obstruction or encroaches upon the lumen of the bowel.

The ulcerative type is frequently associated with the nodular, but in a typical instance ulcerative tuberculous colitis is the primary lesion. However, it is possible for tuberculosis to be associated with it in other parts of the body. This type is evidenced by irregularity of bowel contour in the roentgenogram; in the terminal stages it produces obstruction.

The fibrous type is synonymous with the so-called hypertrophic and is manifested by a marked increase of fibrous connective tissue. In this type the tubercles are discrete and relatively sparse. The large amount of fibrous tissue in this type indicates a marked resistance on the part of the individual. It is the terminal stage of healing tuberculous colitis and peri-

colitis. This type gives practically the same roentgen picture as the ulcerative.

The technic of the examination is not difficult. In fact, it is the same as is used for all other diseases of the intestine. In the Mayo Clinic the enema is ordinarily employed; when necessary the ingested meal is used; in a few cases both methods may be necessary. The enema is preferable since it demonstrates small irregularities of contour by actually outlining the bowel wall, whereas the ingested meal is so unevenly distributed throughout the normal bowel that its irregularity cannot be distinguished from that due to disease. This is especially true in cases with little involvement. If the enema is employed the colon is filled under observation up to and including the cecum. If the ingested meal is given, observations with the screen are made at intervals from the sixth to the eighteenth hour. Plates are made as a matter of record and for study.

The roentgenologic signs of tuberculous colitis are:

1. Filling-defects.
2. Spastic phenomena.
3. Obstruction.

The first and most important roentgenologic sign of tuberculous ileocecal colitis is the filling-defect, which is due to the ravages of the disease plus spastic manifestations. It is best seen during the screen examination with the opaque enema. Under pressure of the enema the cecum and ascending colon are seen to fill irregularly and are decidedly narrowed in their transverse diameter. The normal haustral markings are absent and Bauhin's valve is usually incompetent. After the pressure of the enema is relieved by shutting off the flow the involved area usually empties and remains emptied while the remainder of the colon may retain the enema for some time.

The filling-defect and localized absence of barium shadow in the cecum and ascending colon are not entirely characteristic of tuberculous colitis, for I have seen them in ulcerative carcinoma of the cecum and chronic ulcerative colitis. Stierlin[2] has reported a case of carcinoma in the ileocecal coil with similar findings. Nevertheless, a lesion of the cecum and ascending

colon without the physiologic barium shadow should always suggest the possibility of tuberculosis, and tuberculosis should be looked for in other parts of the body, particularly the lungs. If tuberculosis can be definitely demonstrated in the lungs, the lesion of the cecocolon, whether there is an absence of the physiologic barium shadow or not, is most likely tuberculous colitis.

Hypermotility has been emphasized by Brown and Sampson[3] as an important roentgenologic sign of tuberculous colitis. The term hypermotility can hardly be applied to this phenomenon, because strictly speaking hypermotility refers to the passage of bowel contents at an increased rate along the entire alimentary canal. Hypermotility in our cases was usually due to diarrhea or achylia and was of no more value as a diagnostic sign than a six-hour retention in the stomach would be. The gap in the barium shadow, I believe, does not represent hypermotility, but is the effect of diffuse infiltration of the bowel wall which produces rigidity of the part of the intestine affected. It is apparent from this that the physiologic functions of the diseased segment of the colon have been lost and the barium passes through it without hindrance, just as it does through a stomach diffusely infiltrated with cancer. In the absence of diffuse infiltration spasm stiffens the walls, giving the same motoric effect.

Béclère and Mériel[4] state that an ulcerated mucosa manifests its irritability by an exaggeration of muscular peristalsis with an abnormally rapid progress of the contents of the intestine. I have never observed this muscular peristalsis, but I *have* seen marked spasm of the musculature of the colon due to irritability from an ulcerated mucosa, and I am inclined to think that Béclère meant spasm when he said peristalsis. Stierlin is evidently of the same opinion as I, for in discussing the same subject he mentions no acceleration of motility. Indeed, it has been demonstrated in operations, when the patient is under the influence of narcosis, that this spasmodic condition does exist and its extent is in proportion to the extent of the lesion. For example, if a solitary lesion is present the spasm is localized

and analogous to that seen in gastric ulcer. In this early stage of the disease usually there is no gap in the barium shadow of the ingested meal, but the irregularity of contour due to spasm may be visualized by the opaque enema even if the lesion is not demonstrable.

Stierlin, in 1911, first pointed out the absence of a physiologic barium shadow in the cecum and ascending colon in tuberculosis of the ileocecal coil. Much to his surprise at a time when normally he expected to show the cecum and ascending colon in roentgenograms, no shadow was visible. In its advance the shadow seemed to skip the cecum and the ascending colon. In this country Pirie[5] was the first to notice this phenomenon. By observations at half-hour intervals, continued for from four to twelve hours, he was able to prove that the tuberculous cecum does not retain the barium which normally accumulates there.

Spasm is a manifestation which to a greater or less degree accompanies many if not all gastro-intestinal lesions. It is one of the most perplexing conditions with which the roentgenologist has to deal. For instance, lesions so slight as to cause no irregularity of contour demonstrable in the roentgenogram may exhibit marked deformity and narrowing due to spasm. Indeed, the absence of barium from an involved area of the bowel is caused usually by spasm and infiltration of the intestine rather than by hypermotility. This type of spasm is intrinsic in origin and constant in situation; it is present at a second examination and cannot be effaced by antispasmodics.

In the cases we have seen tuberculosis has been more frequent in the small than in the large bowel. The lesions are seen most often in the ileum and the jejunum, but the latter is less frequently affected. They occur in the bowel anywhere from a few inches to one foot or more apart and usually become confluent near the ileocecal valve. The affected areas are not more than one-half to three-quarters of an inch in width. They are slightly elevated, may or may not be studded with tubercles, and involve the entire circumference of the intestine. Palpation of the areas reveals the presence of ulcers in the mucosa.

There is no definite roentgenologic sign of tuberculous enterocolitis other than that of obstruction which may not be demonstrated except in the terminal stages. Delay beyond six hours in the small bowel, as well as irregular filling and segmentation, may or may not be significant of the disease in the small intestine.

Case 268,386, a woman aged 50 was first seen in the clinic April, 1919. In December, 1917 a cholecystotomy had been performed elsewhere and a tumor of the intestine was excised. In September, 1918 the gallbladder was again drained. The patient complained chiefly of stomach trouble. One and one-half years before examination she began to lose strength and weight, and one month later attacks of pain in the abdomen occurred. The pain did not radiate and lasted for from one to four hours; it was constant, and nausea and vomiting were frequent during attacks. There was no constipation nor diarrhea; the weight loss was 50 pounds in three months.

An operation for gallstones was performed; none were found. The gallbladder was drained and a small tumor involving the intestine low on the right side was excised. No relief followed, and after eight months of suffering the patient was again explored. The gallbladder was drained with negative results. The hemoglobin was 48, the Wassermann test was negative; the urinalysis showed albumin 2; gastric analysis: total acidity 40; free hydrochloric acid 0, and food remnants 0. The roentgenologic examination of the chest was negative; the stomach was negative. Examination of the colon with the opaque enema, revealed irregular filling of the cecum (Fig. 562).

A clinical diagnosis was made of carcinoma of the cecum, and secondary anemia.

An operative diagnosis was made of tuberculosis of the cecum, terminal ileum and ileocecal valve. The pathologist reported tuberculous ulcers of mucosa of the cecum, ileocecal valve and distal ileum.

Case 285,818. August, 1919 a woman aged 20 came to the clinic who gave a history of having had fever, cough, and night sweats in the spring of 1918. Loss of weight and weakness followed and in February, 1919 pneumothorax was performed. This operation was repeated eight times during the next six months. Pain in the abdomen, always in the center and not associated with diarrhea, was noticed in December, 1918. The examination of the urine was negative. The hemoglobin was 55; the erythrocytes 3,240,000. The roentgenologic examination of the chest showed pulmonary tuberculosis, retraction of the left lung to the midclavicular line, and pneumo-

thorax. Examination of the colon with opaque enema revealed a narrowing and irregularity of the cecum and ascending colon (Fig. 563). Bauhin's valve incompetent. The cecocolon emptied as soon

FIG. 555.—Case 149,397. Cecal tuberculosis. Obstruction at O.

FIG. 556.—Case 161,981. Cecal tuberculosis. Obstruction and filling-defect at F. D.

FIG. 557.—Case 111,425. Cecal tuberculosis. Involved area, F. D.

FIG. 558.—Case 128,505. Cecal tuberculosis. Filling-defect, F. D.

as the pressure of the enema was relieved. Diagnosis: Tuberculosis of the ileocecal coil. Operative findings: Intestinal tuberculosis.

Case 149,397, woman, aged 52. Ten years ago she had a surgical exploration for a tumor of the right lower abdomen. She was told

that it was sarcoma; resection was not done. For a year subsequently she was treated with the x-ray. About six months after the exploration an abscess formed in the region of the scar and was opened. This has recurred once or twice since. She thinks the tumor has increased

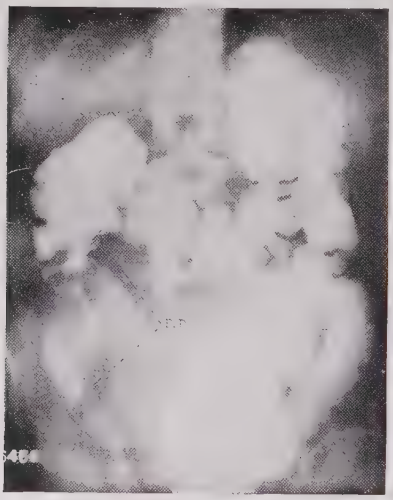

Fig. 559.

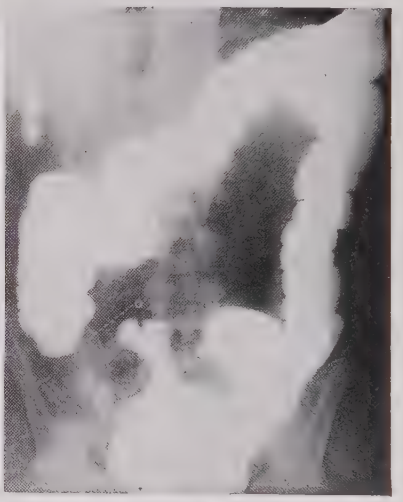

Fig. 560.

Fig. 561.

Figs. 559, 560, 561.—Tuberculosis of cecum. F. D., filling-defect. O, obstruction.

slowly in size, but no definite increase lately. For three months she has had diarrhea with one to four stools daily. Some irritation of bladder recently. Weight loss, 24 pounds in two years. Hemoglobin 60. Hard irregular mass in right iliac fossa. Roentgen findings:

Enema obstructed in upper ascending colon, entire cecal region unfilled (Fig. 555). Findings at operation: Hyperplastic tuberculosis of cecum, forming a large tumor with a fistula, involving the entire cecum and ascending colon. Ileum involved on peritoneal and submucous coats for about 30 cm. Glands involved; some localized peritonitis in vicinity. Right Fallopian tube implicated. The growth is 10 cm. in diameter and 20 cm. long, filled with scar tissue. Operation:

Fig. 562.—Tuberculosis, ileocecal coil. Irregularity cecocolon at a. Bauhin's valve incompetent.

Resection of the right Fallopian tube, 30 cm. of the ileum, appendix, cecum, ascending colon, hepatic flexure and part of the abdominal wall about fistula. Anastomosis with Murphy button, end to side. Pathologist's report: Tuberculosis with glandular involvement.

Case 161,981, man, aged 28. Appendectomy three years ago. Fourteen months later, resection of portions of small and large bowel for "tumor and partial obstruction." Previous to the first operation he had three attacks of severe cramping pain in the right lower abdomen with nausea. After the first operation he had similar attacks but less severe. After the second operation he was well for eleven months, then attacks recurred with nausea and vomiting, coming at first at

intervals of one to three weeks, now almost daily. For six months he has noticed a mass in the right iliac fossa. Hacking cough for two or three years; rarely raises anything. Weight loss, 21 pounds in six months. Hemoglobin 79. Moderately movable mass in right iliac fossa. Roentgen examination of chest shows diffuse tuberculosis of both lungs. Roentgen findings: Concentric filling defect of cecum, corresponding to an obstructive mass (Fig. 556). Findings at opera-

Fig. 563.—Tuberculosis, ileocecal coil. Note narrowing and irregularity of cecum and ascending colon at a. Bauhin's valve incompetent.

tion: Large tuberculous tumor of the cecum, involving about 30 cm. of the terminal ileum. Many tuberculous areas throughout the colon, chiefly in the right half. Operation: Resection of the right half of the colon. Low ileosigmoidostomy by suture. Pathologist's report: Tuberculosis.

Case 111,425, woman, aged 32 years. Shortening of round ligaments and perineorrhaphy six weeks ago, elsewhere. At that time a growth involving the cecum was found. A year ago she had an attack of constipation and cramps, relieved by purgation but followed by low-grade fever for two weeks. Since then the constipation has been

controlled by cascara and enemata. Occasional slight colic; some pain in the right upper abdomen; quite sore over cecal region. Nothing abnormal in stool; no urinary symptoms. Hemoglobin 85. Tenderness right iliac fossa. Pulmonary examination shows tubular type of breathing and delayed expiration both apices. Roentgen findings: Filling-defect of cecum with marked narrowing and irregularity (Fig. 557). Findings at operation: Tuberculosis of the cecum, involving terminal ileum and ileocecal valve. Operation: Resection 25 cm. of ileum, cecum, appendix and ascending colon. End-to-side anastomosis by suture.

Case 128,505, woman, aged 24 years. In good health up to three months ago when she developed soreness and tenderness in the right lower abdomen. Later her physician discovered a tumor in this region. She was explored elsewhere one month ago, and tuberculosis of the cecum was found. Since then she has been losing weight; she has had an afternoon rise of temperature and a few night sweats. The stools have been loose for several months but have never contained blood. A slight cough, but no expectoration. Former weight 124; present 92; emaciated; looks anemic. Hemoglobin 75. Boggy tumor mass in right iliac fossa; not tender. Roentgen findings: Filling-defect of cecum and ascending colon (Fig. 558). Findings at operation: Hypertrophic tuberculosis of cecum. Mass about 20 cm. in diameter. Huge glands along the spine. Terminal ileum involved. Free fluid in abdominal cavity. Operation: Ileocolostomy. Attempt at resection not advisable.

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CHAPTER XXVI

CHRONIC ULCERATIVE COLITIS

Chronic ulcerative colitis is a disease little known in this country but is constantly attracting more attention from both the medical and surgical members of the profession. This is largely due to the fact that our methods of recognizing the disease have become fairly well established. The latter was first described as a disease entity in 1888 by White[1] of England. It has also received considerable attention from German authors, notably Kienböck,[2] Schmidt[3] and Stierlin.[4]

Chronic ulcerative colitis may be defined as a chronic inflammatory condition of the colon, of obscure etiology, showing redness, thickening and infiltration of the mucosa, which later results in granulation tissue, polyps, pedunculated papillomas, chronic ulceration and perforation.

The disease, which runs about the same clinical course in both sexes, is almost twice as common in males as in females. People living in rural districts are more often affected. The cases examined in the Mayo Clinic, however, seemed to indicate no particular geographic distribution.

Logan,[5] of the Mayo Clinic, in reviewing 117 cases, says the disease almost invariably begins with diarrhea, watery at first but containing fresh blood and pus later on, the number of stools varying from two to fifteen daily. Pain is not a prominent symptom; the patients may go about for years without much inconvenience other than diarrhea. Perforation, which occurs occasionally, may cause localized peritonitis, pain, slight elevation of temperature and reaction.

Diagnosis is made on the history of the case together with proctoscopic and x-ray examinations. The proctoscope should be employed in the examination of every case; its use in diagnosis is limited to the early cases involving the lower bowel. The

x-ray, on the other hand, will show the extent of involvement and points of constriction. It will demonstrate those cases beginning high up in the colon without involvement of the sigmoid or rectum.

In his monograph, Schwarz[6] describes and illustrates the roentgenologic findings in a few cases each of chronic catarrhal, mucous and ulcerative colitis. One feature common to all three varieties was a local or general narrowing of the colon, which was smooth and unhaustrated. In the catarrhal type, the contracted areas changed their situation rapidly. Notwithstanding the narrowing, the enema filled the colon very quickly. Besides the wandering diffuse contractions, exaggerated peristalsis and antiperistalsis were noted, indicative of a hyperirritability. In the mucous type, with the opaque meal, the shadow of the colon was persistently narrow and had a very peculiar flecked and marbled appearance, due probably to the bismuth-holding clumps of mucus. The ulcerative type showed a narrow, stippled colon-shadow with delicate arborizations.

The cases of mucous colitis and catarrhal colitis which I have examined with the ingested meal or enema either gave negative findings, or at most showed only a vacillating spasticity of the bowel which had little diagnostic import. Permanently contracted and unhaustrated areas were not noted in any instance. I have not seen barium-holding clumps or barium-ized mucous casts which might be considered pathognomonic of mucous colitis. This may have been due to the fact that they are not constant findings or that our cases were too recent. On the other hand, our cases of colitis of the granulating or ulcerating type have given consistently positive roentgen findings. Examination was by clysma usually. The most striking roentgen characteristics noted were rapid filling of the colon, which is narrow and ribbon-like throughout without haustral markings. The incompetence of the ileocecal valve, which has been noted rather constantly in cases of chronic colitis, is not of itself diagnostically important, since we find it in a very high percentage of all cases examined, whether normal or

pathologic. But, in conjunction with other roentgen signs of chronic colitis, it may have some corroborative value, when the barium runs into the ileum spontaneously and profusely. The papillomatous condition of the mucosa can sometimes be demonstrated by the x-ray, especially if the patient is examined again after expelling the enema. In a few instances the disease was quite localized, showing rather smooth constricted (healed) areas or an irregularity of contour due to perforation, suggesting neoplasm. These roentgenologic phenomena are not due to spasm, but result from organic changes occurring in the bowel wall. Furthermore, they are permanent and cannot be changed in their main appearances and characteristics by the administration of antispasmodics to physiologic effect prior to a second roentgen examination. Besides, enterospasm has not been observed during the roentgen examination in this type of colitis.

There are certain other conditions of the large bowel in which some of these phenomena may also be found to a varying degree; but, as a rule, they can be eliminated either by a correlation of the roentgen findings with the clinical data, or the roentgen picture alone may definitely indicate a lesion other than colitis. For example, in an occasional case of chronic constipation, the large bowel may be smooth and show no haustration. Exceptionally also, in cancer of the colon, the unaffected portion of the bowel may have smooth, unhaustrated borders. However, these findings are not constant. In such instances the lack of haustration is doubtless due to relaxation of the longitudinal muscle bands—the tenia.

It is worthy of note that in a limited number of cases of chronic endamebic colitis, I did not find a roentgenologic picture in any measure differing from the normal. The group included cases of long standing and of recent exacerbations, but none that were prostrated. Sanford[7] has emphasized the fact that the entire syndrome of chronic endamebic colitis as seen in the North is not so severe as in the South and the tropics; this may explain the absence of marked pathologic changes in the bowel wall. However that may be, I believe that the roentgen

examination offers distinct value in the differentiation of these two diseases, especially as seen in this latitude. All the x-ray findings were logically accounted for by the organic changes found at operation and at necropsy, notably pronounced infiltration, thickening, contraction, granulation, ulceration and perforation.

Following are some case histories:

Case 125,312, man, aged 24 years. Persistent diarrhea for twelve years. Ordinarily he has about five bowel movements daily, but

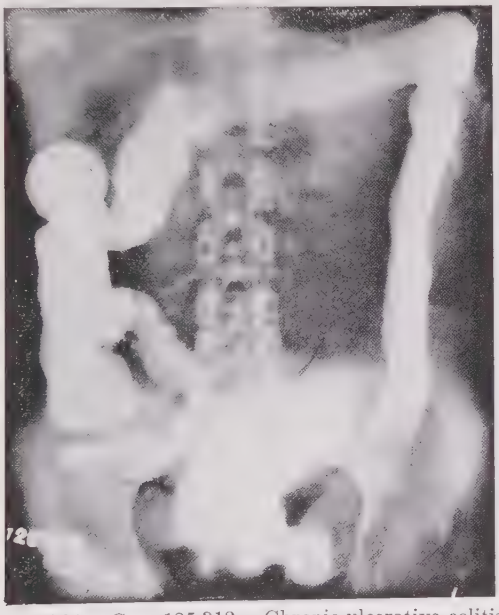

FIG. 564.—Case 125,312. Chronic ulcerative colitis.

there are periods off and on, lasting several days, when he has eighteen or twenty stools daily. At these times the stool s very thin and bloo dy and contains mucus. No relief has been obtained from treatment with various drugs, including emetine. No loss of weight. Suggestion of a movable rounded mass at cecum. Proctoscopic examination: Marked granular colitis; bowel thick, very tender and bleeds easily; no ulceration found. Stool report: No parasites found. Roentgen findings: Smooth, narrow colon, devoid of haustra (Fig. 564). Findings at operation: Much congestion of walls of colon. Prolapsed cecum. Appendix adherent to ascending colon. Operation: Appendicostomy.

Case 146,817, man, aged 38 years. For two years he has had attacks of diarrhea lasting from two weeks to three months. The stools range in number from five to twenty daily. They are of rice-water character, odorless or not offensive, with mucus and blood. During the past three months there has been much bright red blood in the stools. Occasionally he has cramps and tenesmus before the bowels move. Weight fluctuant; present loss, 26 pounds. Hemoglobin 70. Wassermann negative. Slight gurgling over cecum. Little tympanitis. No rigidity. Proctoscopic examination: No evidence of ulceration. Stool report: No parasites, tubercle bacilli, red

Fig. 565.—Case 146,817. Chronic ulcerative colitis.

blood corpuscles or pus cells. Roentgen findings: Colon markedly contracted and unhaustrated throughout, indicating a chronic inflammatory process (Fig. 565). Clinical diagnosis: Chronic ulcerative colitis. Findings at operation: Colon contracted to about the caliber of the small intestine. Wall moderately thickened, vessels injected and the bowel of deep reddish color. General appearance of a plastic peritonitis. Condition seemed to be present from cecum to rectum, gradually increasing from cecum down. Sub-acute appendix. Operation: Brown operation (ileostomy). Cecum brought up through separate incision for colostomy later if advisable. Appendectomy secondary.

Case 107,128, man, aged 54 years. Diarrhea for eleven years. Daily average of six stools, chiefly about breakfast time. He has often noted streaks of bright blood in the stool. Some soreness in the lower abdomen, but never any distinct pain. Only slight loss of weight. Physical examination: Hemorrhoids. Mucous membrane of rectum feels granular and edematous. Hemoglobin 30. Wassermann negative. Roentgenogram of chest shows healed tuberculosis of right upper lobe. Proctoscopic examination: Diffuse granular colitis; bowel gradually narrowed to the diameter of about 3 cm. Stool report: Loose brown stool with mucus, red blood corpuscles and pus;

Fig. 566.—Case 107,128. Chronic ulcerative colitis. Sausage-like colon. No haustration.

no tubercle bacilli or parasites. Roentgen findings: Narrow, smooth, sausage-like colon. Hepatic and splenic flexures ptosed (Fig. 566). Clinical diagnosis: Chronic ulcerative colitis. No operation.

Case 126,013, woman, aged 25 years. About eight years ago each autumn for two or three years, she had attacks of hemorrhage from the bowel. The hemorrhage occurred with nearly every defecation and continued for two weeks to two months. With the attacks there was some pain in both lower abdominal quadrants. Five years ago she passed a concavo-convex mass of material about 8 cm. long which seemed to be made up of hair. Following this no hemorrhage

FIG. 567.—Case 126,013. Chronic ulcerative colitis.

FIG. 568.—Case 121,271. Chronic ulcerative colitis.

FIG. 569.—Chronic ulcerative colitis involving the left half of the colon. Note the marked narrowing and absence of haustral markings in the descending colon and sigmoid. A, site of former colostomy.

FIG. 570.

occurred until six months ago, and again six weeks ago. Physical examination shows tenderness in left lower quadrant. No hemorrhoids. Roentgen examination of chest shows healed tuberculosis of

Fig. 571.

Fig. 572.

right apex, and thickened pleura forming pocket over periphery of left lung. Proctoscopic examination: Generalized, chronic inflammatory condition of bowel as far as could be seen; bleeds easily. Stool

Fig. 573.

report: Negative for tubercle bacilli; no parasites found; blood present. Roentgen findings: Smooth, narrow, unhaustrated colon, suggestive of chronic colitis (Fig. 567). No operation.

Case 121,271, man, aged 48. Good health up to twenty-two years ago, then onset of diarrhea for six months, with two or three stools daily; no pus or blood. Well for a year, then recurrence of the diar-

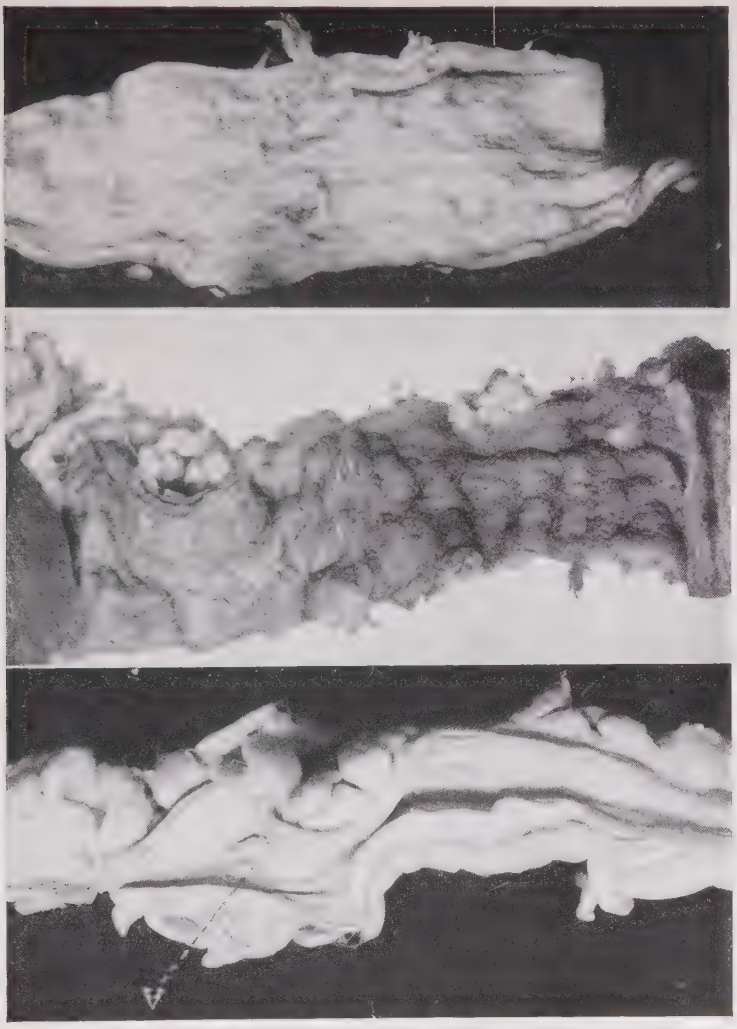

FIG. 574.—Section of colon showing atrophy and smoothing out of mucosa with constriction at one end. (*a*) Polyp; (*b*) specimen demonstrating hemorrhagic areas in mucosa; (*c*) specimen showing multiple ulcers, with smoothing out of mucosa.

rhea. For the past year he has had a daily diarrhea—about four watery, slimy stools. Slight mid-abdominal gas pains after movements. Underweight 80 pounds for the past five years. Hemoglobin

Fig. 575.—Chronic ulcerative colitis. The constricted areas are organic and not spasmodic.

Fig. 576.—Chronic ulcerative papillomatous colitis.

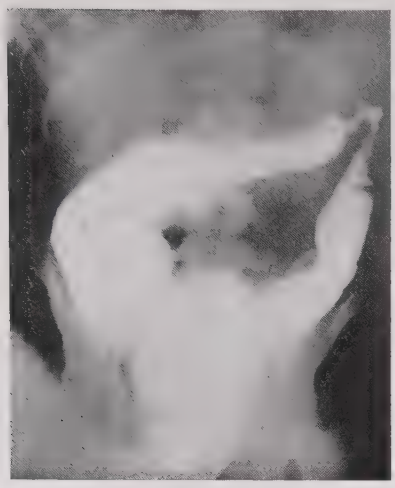

FIG. 577.—Marked chronic ulcerative colitis involving chiefly the transverse colon Confirmed by necropsy.

FIG. 578.—Chronic ulcerating, perforated, papillomatous colitis. Necropsy confirmation.

80. Total gastric acidity 12; all combined. Proctoscopic examination: Diffuse superficial ulceration of bowel, not typical of any especial lesion. Stool report: Loose brown stool, chiefly mucus; red blood and pus cells; cercomonads. No amebæ. Roentgen findings: Colon narrow and more or less smooth throughout (Fig. 570). Clinical diagnosis: Chronic colitis. No operation.

Roentgenograms of other cases of chronic ulcerative or granular colitis, confirmed at operation or necropsy, are shown

Fig. 579.—Roentgen findings September, 1917. Chronic ulcerative colitis. Note narrowing of colon, absence of all haustral markings and incompetent Bauhin's valve (see Fig. 580). Operative findings: Chronic ulcerative colitis. Operation: Brown.

in figures 571 and 572. Figure 572 was a case of chronic granular colitis; the peculiar appearance of the descending colon is due to a partial involuntary evacuation of the enema before the roentgenogram was made; figure 573 is a photograph of a portion of the bowel at necropsy. Other specimens are reproduced in Fig. 574.

FIG. 580.—Roentgen findings July, 1919, marked narrowing of the bowel more especially the transverse colon. No visible haustra. Same case as Fig. 599. This case is interesting from the standpoint of treatment. Instead of showing improvement after operation the x-ray examination would seem to indicate that the condition has progressed, in spite of a marked improvement in the patient's general condition. Bowel movements per rectum every three to fourteen days. Patient has noticed no blood for more than three months. It is possible that the extreme contracture of the bowel is due to non-use rather than progression of the disease. The patient's better physical condition would seem to suggest this.

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CHAPTER XXVII

CHRONIC INTESTINAL STASIS AND CONSTIPATION

Delayed progress of food material through the alimentary tract has been given renewed interest by the work of Sir Arbuthnot Lane.[1] Prior to his investigations, retarded passage of the fecal current and the symptoms arising therefrom had been broadly covered by the term "constipation," and considered chiefly as a functional disorder affecting particularly the lower bowel. But, by extending the field to include delayed transit through any part of the intestinal tract, from any cause, advancing novel views as to etiologic relationships and surgical treatment, and inventing the term "intestinal stasis," Lane has created an apparently new and important domain. From his work and that of his followers and opponents an extensive literature has arisen. Notwithstanding this, the matter has not as yet crystallized into a definite and accepted entity susceptible of ready and clear understanding.

Einhorn[2] contends that "visceroptosis giving rise to intestinal angulations (designated as kinks by Lane) and the formation of partial stenoses with delayed prochoresis," originated with F. Glenard. Einhorn states further that the theory of intestinal stasis leading to the absorption of poisons within the intestine, or auto-intoxication, was advanced long ago by Bouchard, Combe and others. However, Lane has at least developed these theories to greater lengths and logically carried them to courageous surgery.

Lane has defined stasis as "such a delay of the contents of the intestine in some portion of the gastro-intestinal tract, but more particularly in the large bowel, as allows the absorption into the circulation of a larger quantity of toxic material than can be dealt with effectually." "This delay," he states, "results from a mechanical alteration in the normal arrangement of the drain-

age apparatus. In early life it is produced by an abnormal distention of the intestine, consequent on too frequent feeding, or by the use of articles of diet of an unsuitable nature. Later, it is brought about and accentuated by the erect posture of the trunk which is assumed from the time of getting up until going to bed." He holds that the dragging strain of the intestine upon its principal points of support tends to the production of bands and kinks at these points. The bands, he states, are not inflammatory but evolutionary, that is to say, they represent a compensatory effort of nature. The points at which these bands and resulting kinks occur more commonly, he claims, are:

1. The pylorus.
2. The terminal coil of ileum.
3. The outer aspect of the cecum and ascending colon.
4. The hepatic flexure.
5. The splenic flexure.
6. The sigmoid loop.

Symptoms of the auto-intoxication consequent upon stasis include: Loss of fat, impaired circulation of the blood, partial inhibition of respiration which is often entirely diaphragmatic, staining of the skin, offensive perspiration, pain and weakness in the skeletal muscles, morning headaches, and increased susceptibility to infections of the gums, tuberculosis, rheumatoid arthritis, gout, etc. Lane claims, further, that as a result of enlargement and abrasion at the point of stress local ulcers and cancers occur, and numerous remote lesions are set up by the systemic toxemia and irritation. This inclusive feature of Lane's conception of stasis makes the subject momentous. If it can be established that ulcers and cancers of the digestive tract, goiter, mammary cancer, tuberculosis, etc., are sequelæ of intestinal stasis, then the diagnosis and treatment of the antecedent condition are of vast import.

Lane's theory of stasis has been vigorously combated by Einhorn, Bassler,[3] Hurst[4] and many others. Einhorn objects to calling the digestive canal a "drainage-tube," and comparing it to a sewer system, in which any clogging must cause disaster.

He considers intestinal stasis only another name for constipation, and holds that constipation does not cause auto-intoxication. He believes that if we did not need the colon we would not have it, or it would show decided signs of degeneration, which it does not, hence ileo-colostomy or colectomy is not justifiable for functional disturbances. Bassler states that he has had 167 cases which had Lane kinks, but only 5 of these showed delayed prochoresis. He thinks that Lane bands are probably physiologic, that sagging of the transverse colon does not necessarily mean stasis, and that operation should be reserved for intestinal obstruction, pure and simple. Daniel[5] disagrees with Lane as to the origin of bands and kinks, and holds that they are due to local peritonitis resulting from bacterial activity. Hurst believes that ileal stasis is a normal phenomenon resulting from the action of the ileocecal sphincter; although it may be increased by spasm of the sphincter as a result of disease in the neighborhood of the cecum. He states, further, that ptosis of the intestines does not lead to stasis, except in rare instances at the splenic flexure, a pelvic cecum or transverse colon being compatible with perfect health and normal intestinal action. He is of the opinion that in most cases of constipation a single part of the bowel is involved; and that even in the cases in which the entire colon is involved medical treatment almost invariably succeeds.

Keith,[6] who does not accept Lane's theory of stasis, and denies that kinks produce delay of the food stream, thinks that he has found a possible explanation in his own observations. He has noted in the myenteric plexus (Auerbach's), or, rather, intermediate between it and the muscle-fibers, neuromuscular cells, partaking of the characters of both nerve and muscle, which he calls "nodal tissue" because of its similarity to nodal tissue in the heart. He finds that this tissue is plentiful in the neighborhood of the sphincters of the digestive tube, as well as at certain other points, and suggests that, like the nodes in the heart, each local aggregation of nodal tissue serves as a pacemaker for rhythmic contraction (peristalsis) in the zone distal to it. He does not think it over-presumptuous to suppose that irregulari-

ties of impulse-conduction may occur in these nodal systems and cause stasis in the same way that "heart-block" is produced. The effect of disordered conduction, he believes, is not limited to the related sphincter, but extends to the bowel segment beyond, and that disturbance of rhythm in any one zone tends to upset the rhythm in other zones. While Keith's theory does not carry us far toward the final solution of stasis, it offers a plausible explanation of the manner of its production, and again brings into the foreground the musculature of the alimentary tract.

Moynihan[7] seems to speak wisely when he says: "I do not hesitate to say that the whole question of stasis is one which will have to be considered by all of us and be put to the proof. It cannot be dismissed with a shrug or a sneer, for there is truth in the matter. Among much that is dross there lies a nugget of pure gold."

It is quite obvious that the roentgen-ray offers a convenient means for demonstrating the evidences of stasis. Accordingly, Jordan[8] who early took up the work for Lane, has called attention to the following roentgenologic signs:

1. Dilatation and writhing peristalsis of the duodenum. He lays much emphasis upon duodenal distention, claiming that when this is present, other evidences of stasis will also be found, and that, conversely, in the absence of duodenal dilatation stasis is not likely to exist.

2. Ileal stasis, with delay of the intestinal contents in the terminal ileal coils. In some instances this may be due to dropping of the lower coil so that the terminal segment has a steep ascent to the ileum. In others there is obstruction by an adherent appendix, or by a kink.

3. Kinks. The points where Jordan finds kinks most commonly are at the duodeno-jejunal juncture (hence the duodenal dilatation above mentioned), the terminal loop of the ileum (particularly about 10 cm. from its terminus), the hepatic flexure, the splenic flexure, and the sigmoid. These kinks are evidenced by localized narrowing, fixation (as shown by lessened movement on palpation, forced respiration and change of pos-

ture) tenderness, dilatation proximal to the stenosis and delay of the intestinal content.

4. New formed bands about the appendix, kinking and fixing it.

5. Elongation, dilatation and looping of the rectum.

These findings have formed the groundwork of the roentgenology of stasis. To a varying extent and with additions they have been adopted by many other observers. Thus Pfahler[9] has noted kinks, spasms, twists, and adhesions in various parts of the bowel. He has observed obstruction at the splenic flexure by a gas-distended splenic loop. Case[10] sees kinks less frequently, but often finds the distal colon to be spastic. He dwells upon incompetence of the ileocecal valve as a factor in stasis.

Brown[11] reëmphasizes the relation of the enteroptotic habitus to visceral ptosis and hence to stasis. Cole[12] says that the whole subject of stasis centers around the roentgenologic findings; therefore, it is essential that the roentgenologic foundation be sound, solid and scientific. He vigorously condemns the use of roentgenograms as a weapon with which to urge surgical procedure for some preconceived diagnosis.

The validity of the signs of stasis exploited by Jordan and his followers is not accepted by all roentgenologists. Hurst[13] asserts that intestinal stasis does not lead to duodenal kinking, dilatation or ulceration, and points to the fact that duodenal ulcers are associated with an unusually rapid passage of chyme out of the stomach and through the whole of the small intestine. He also says that when the stomach empties rapidly, the duodenum contains more barium at a given moment. Hence it appears dilated, the normal peristalsis and segmentation are rendered more clearly visible, and this accounts for so-called "writhing." Segmentation in the terminal ileum is very active and this, he thinks, may be mistaken in the roentgenogram for organic narrowing. As to incompetency of the ileocecal valve he feels that the valve does not normally prevent regurgitation into the ileum, as he has seen this with a pressure as low as 1 foot of water. Regurgitation is not due to antiperistalsis, he claims, as x-ray

investigations have shown that antiperistalsis does not occur in man under normal conditions.

Regarding stasis, Mixter[14] says: "Since the advent of the roentgen-ray much has been learned and many mistakes have been made. It is safe to say that the old ideas of the positions of the abdominal viscera have undergone a great change in the last few years. Their positions and shapes are becoming better known, and what a short time ago were considered malpositions or malformations are now known to be but slight variations from the normal, if there is any such thing as a normal arrangement. The large intestine is a marked example of this rule; it never lies in the regular lines and curves as shown in the diagrams of the old anatomists. There are innumerable variations, due to congenital or acquired folds of the peritoneum, and many have too quickly decided that anything unusual must be a serious physical defect, and the cause of certain trains of symptoms. * * * Fecal stasis is recognized as an evil, and many operations have been designed and performed for its relief that are useless or do positive harm. * * * Ptosis does not, or should not, always mean operation. The interrelation of fecal stasis and the neuroses and auto-intoxications of all kinds are subjects that require further investigation and study, though day by day and year by year our knowledge is steadily advancing. The medical clinician, the neurologist, the psychologist, the bacteriologist must each do his part, and they should be aided, not overshadowed, by the roentgenologist, whose mechanical findings may so often be misinterpreted."

Speaking as a surgeon, Coffey[15] offers this warning: "Roentgen observation is of inestimable value in the study of these cases, but is, I concede, the most dangerous agent yet placed at the disposal of the unscrupulous surgeon, because it is so convincing to the laity, and at the same time so meaningless when considered independently of the history of the case and not properly interpreted."

Hurst[16] does not seek to minimize the importance of intestinal hypomotility. On the contrary, in his book he has admirably

presented the whole subject of constipation from every viewpoint, including the roentgenologic. A summary of his observations may serve to correct the spreading assumption that constipation is a purely mechanical matter. Admitting wide variations within the normal, he says: "For practical purposes an individual may be considered constipated if his bowels are not opened at least once in every forty-eight hours. * * * Constipation may be defined as a condition in which none of the residue of a meal taken eight hours after defecation, is excreted within forty hours." He divides constipated persons into two great classes: First, those in whom passage through the intestine is delayed, but defecation is normal. Second, those in whom there is no delay in arrival of fecal material at the pelvic colon, but final excretion is not adequately performed. In the first class delayed prochoresis may be due to:

A. Deficient motor activity of the intestine.

B. Excessive force required to carry the feces to the pelvic colon.

The *A* group may have as causes: (1) Weakness of the intestinal musculature, which may be constitutional or senile, or the result of chlorosis, cachexia, rickets, fevers, overdistention by gas, obesity (fatty degeneration of muscle) etc. (2) Deficient reflex activity of the intestine from insufficient food; insufficient chemical and mechanical excitants of intestinal activity, excesive digestion and absorption of food (greedy colon) or deficient exercise. Reflex activity may be impaired also by catarrhal conditions of the mucosa, long-continued irritation by purgatives, astringents (tannin in tea and coffee) or by depression of the nervous system (neurasthenia, hypochondriasis). (3) Inhibition of motor activity by lead poisoning, depressing emotions, or painful abdominal viscera (ovaritis, cholecystitis, appendicitis). (4) Spasticity of the intestinal musculature (patients usually neurotic, often brain-workers). A localized spasticity of some part of the colon is often accompanied by spasm of the sphincters.

The *B* group may result from obstruction by an excess of

feces, or dry hard feces (insufficient supply of water, excessive loss of water by other channels, excessive absorption of water), deficient fat in the diet, obstruction by organic stricture (nearly always malignant), kinking of the intestine (of which he has noted but one instance), pressure on the intestine by tumors without, and chronic intussusception.

For the second of the two great classes of constipation he proposes the name "*dyschesia*." The passage of feces to the distal colon may be normal or even unusually rapid, but the act of defecation does not empty the lower bowel as completely as it should. The causes include habitual disregard of the call to stool, weakness of the abdominal and pelvic muscles, weakness of the defecation reflex (tabes), hysteria, hard and bulky feces, functional and organic strictures of the anal canal and sphincter, and pressure on the rectum by a pelvic tumor or retroverted uterus.

Schwarz[17] distinguishes two types of chronic obstipation, the hypokinetic and dyskinetic. In the hypokinetic type the slow transport of the ingested meal is associated with a lessening of peristaltic action in the distal half of the colon, continuity of the fecal mass, belated gradual ejection into the end-gut, and fragmentary emptying. Elongation of the colon is a frequent addition to this syndrome. In the dyskinetic type there is a hyperfunction of the transverse and descending colons, the fecal mass is broken up and separated, and the abnormal contraction of the mid-colon produces a retention in the cecum and ascending colon. Briefly, the first type is atonic, the second is spastic.

Skinner[18] notes four types of constipation which are nonorganic and purely functional. These are as follows:

1. Hypermotility of the proximal colon with increased antiperistalsis. Six hours after the bismuth meal its shadow may reach as far as the descending colon, but at the end of twelve or twenty-four hours the opaque shadows in the cecal and hepatic areas are increased in size while there is little, if any, filling of the pelvic colon.

2. The cecal type, with slow filling of the cecum and long re-

tention of the bismuth there, often associated with a history of recurring appendicitis in the male, and ovarian or tubal symptoms in the female.

3. The atonic type, with ptosis of the colon, including the hepatic and splenic flexures. Bismuth residues may be found in the ileum up to twenty-eight hours after the meal and in the colon up to fourteen days.

4. Rectal constipation. The bismuth reaches the pelvic colon in the usual length of time (about twenty-four hours), but the fecal residue collects in the sigmoid and rectum from the failure of the individual to carry out a rational rectal hygiene.

During the past six years I have examined several hundred cases of constipation with the opaque meal or enema or both. In many instances, notwithstanding an emphatic clinical history, the roentgen findings were trivial and valueless, or even utterly negative. In some cases the information derived from the x-ray appeared to be worth while. Although the examinations were thorough, no obstructive kinks were found, nor were any discovered by the surgeon in those cases which were explored. Angulations of the bowel were noted repeatedly, and in certain planes of view these sometimes seemed to be acute and potentially obstructive, but when observed from another direction the course of the bowel was seen to be curved instead of angular and no stenosis existed. The tremendous variance of opinion among observers as to the frequency of kinks indicates widely different conceptions of this condition.

In several of the cases coming to operation, the surgeon found adhesions of varying extent as a result of former interventions. In one or two instances adhesions were present although no previous operation had been performed. Definite roentgenologic signs of adhesions were lacking, as a rule, even when a former laparotomy had been done, and the presence of adhesions was presumable.

Quite often the constipated colon, as seen with the opaque clysma, showed evidences of atony (Fig. 581). The colon was broad, either in its proximal half or throughout; its outline was

abnormally smooth, the haustra being slow to appear and only slightly marked; its length was increased by redundancy of the distal segments; its capacity was augmented so that additional quantities of the enema were required to fill it. From the roentgenologic standpoint these proofs of atony could hardly be stronger.

FIG. 581.—Redundant, atonic colon. History of severe constipation. Examination by enema. No operation.

On the other hand, though less often, a directly opposite condition was noted, namely hypertonus or spasticity (Fig. 582). The colon was narrow and deeply scalloped with haustra, especially beyond the hepatic flexure; it was usually short, and less than the customary amount of the enema was needed to fill it. It must be granted that neither atony nor spasticity of the colon necessarily betokens constipation, but the finding of either in association with stasis ought to have considerable bearing on the treatment.

I have been unable to confirm any consequential relationship either of ptosis or the so-called insufficiency of the ileocolic valve to stasis.

It might be said that the barium meal test of motility in stasis is an elaborate method of confirming the patient's statement that he is constipated. However, besides this confirmation, which is sometimes expedient, the meal may show not

FIG. 582.—Spasticity of the colon distal from the hepatic flexure. Examination by enema. Marked constipation. At operation a small, subacutely inflamed appendix was found, without adhesions. Colon negative.

only the fact of delay, but the region in which the delay is greatest. As has been stated elsewhere, the meal should be given without previously purging the patient or requiring him to fast, since it is desired to show the progress of the fecal current under usual circumstances. The meal which we employ is a mixture of barium with cereal, the same as is used for testing gastric motility. It is given to the patient at 5 p.m. and the first examination is made the next morning at 8 o'clock. Subse-

quent examinations are made at intervals of twenty-four hours, or more frequently if preferred.

Taking a few of the patients operated on as examples, the bulk of the barium meal was still in the ileum at seventeen hours in one, at twenty-five hours in another. Retention in the colon at seventy-two hours or longer was observed in several instances,

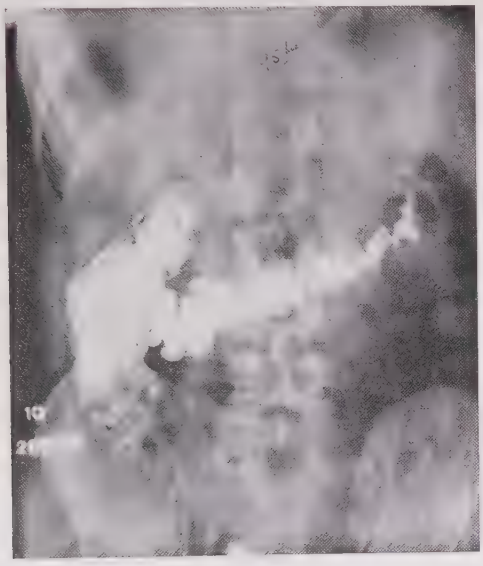

Fig. 583.—Two years previously this patient had been operated on elsewhere because of paroxysmal pain in the right lower abdominal quadrant—appendectomy, colopexy, longitudinal plication of ascending colon. Within a month the pain recurred and the stools had to be kept liquid to avoid a stoppage of the bowel movements. Roentgen examination by the ingested opaque meal showed a large delay in the right half of the colon up to 95 hours.

Operative findings: Tremendous amount of adhesions, involving terminal ileum, cecum, ascending and right half of transverse colon, without marked obstruction, from former operation.

Operation: Resection 8 cm. of ileum, cecum, ascending and transverse colon. Pathologist's report: Wall of intestine exceedingly thin, with very little muscle-tissue.

and in one instance a large amount of barium was still in the colon after two weeks. Retentions were noted in different parts of the colon; sometimes chiefly in the cecum (Fig. 583), sometimes in the distal colon (Fig. 584), and occasionally scattered throughout. Those of our patients who were operated on were

explored, not solely because of the roentgen findings, but because the clinical factors justified surgical intervention. Often there was a history of a previous operation. In some cases this had been done for the relief of stasis, but without success. In view of my own rather indecisive experience and the varying experience of others with the roentgen examination for stasis, any general conclusions can be offered only with diffidence. It would seem, however, that the greatest value of the x-ray consists not in showing organic obstruction but in excluding it, and that, at

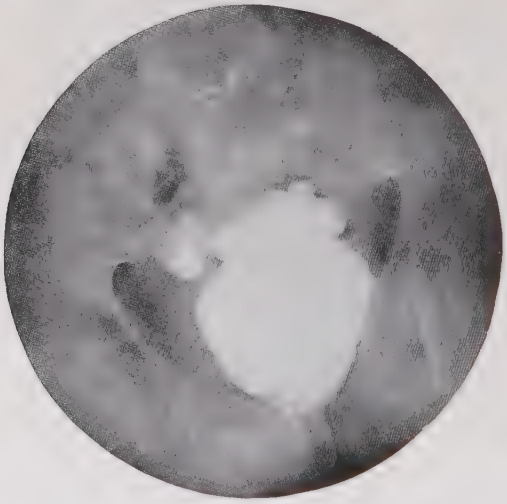

Fig. 584.—Large rectal ampulla containing considerable barium at 72 hours. The patient was very constipated and because of this in association with a marked general arthritis he was sent to operation. Resection of cecum, ascending colon and right fourth of transverse colon. Neither the arthritis nor the constipation were relieved by the operation.

present, clinical considerations largely must determine both diagnosis and treatment.

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CHAPTER XXVIII

CHRONIC APPENDICITIS

While, for manifest reasons, acute appendicitis seldom comes within the purview of the roentgenologist, he has had ample material for study of the subacute and chronic varieties. At the beginning, attention was directed chiefly to the demonstration of concretions in the appendix. Later it was discovered that the opaque meal or enema sometimes entered the appendix, and efforts to distinguish between the normal and abnormal appendix were thus stimulated. Among early writers on the subject was Liertz,[1] who reported a case in which the appendix was visualized after a bismuth meal. Liertz discussed stagnation of the bismuth in the appendix as a possible sign of appendicitis. More recent contributors to the literature include Singer and Holzknecht,[2] Case,[3] Rieder,[4] Groedel,[5] George and Gerber,[6] Cohn,[7] Hurst,[8] Henselmann[9] and Imboden.[10]

Singer and Holzknecht report their findings in 25 cases examined fluoroscopically six hours after the meal. They believe that the radiology of appendicitis has striven in the wrong direction, namely, the demonstration of the bismuth-filled appendix, as this is only occasional and therefore uncertain. They dwell upon tenderness in the appendiceal region as the chief sign, and the location of the appendix is determined not so much by visualizing it as by demonstrating the position of the cecum. Used in this manner, they consider the x-ray of great value in differentiating tenderness of the appendix from tenderness of other organs in the right iliac fossa.

Case was able to demonstrate the appendix in one-third of a large series of cases examined by the bismuth meal. Technically speaking, he believes that it is pathological for the contents of the

colon to enter the appendix, but he does not wish to be understood as holding that every appendix which permits the entry of bismuth is in need of surgical attention. The appendix which remains visible for more than a day or two following the bismuth examination is, he thinks, in proportion to its poor drainage, a dangerous appendix. In those cases in which he demonstrated the appendix, 85 per cent. had definite tenderness corresponding with the shadow of the appendix.

Rieder enumerates among the roentgen signs of appendicitis, the following: Stagnation of the meal in the appendix and ileocecal region; localized pressure-tender point; insufficiency of Bauhin's valve (mentioned by Dietlen); adhesions about the appendicular region; kinking or pulling up of the appendix; and concretions in the appendix.

George and Gerber have succeeded in demonstrating the appendix, either normal or pathological, in about 7 out of every 10 patients examined. They state that chronic appendicitis can be shown in two ways: first, by the ileal stasis which it produces; and second, by actual demonstration of the kinked and adherent appendix. To be safely classed as real ileal stasis, bismuth should be present at least twenty-four hours or longer. "From the presence of marked ileal stasis alone we cannot make a diagnosis of chronic appendicitis," they say, "but we can sometimes infer it." The pathologic appendix may show a bismuth mass which is sharply kinked in one or more places. It may have adhesions to itself, to the cecum, ileum or even to the sigmoid. Retrocecal appendices can sometimes be shown distinctly, and will show more clearly when some of the bismuth has passed out of the cecum. In many instances bismuth will persist in the lumen of the appendix for hours after it is out of the cecum or ascending colon. In one of their cases it persisted as late as five days.

Cohn found the appendix to be an especially mobile organ. Its movements consist not only of a change of position *in toto* but various alterations of its configuration. It does not fill immediately upon the entrance of material from the small intes-

tine into the colon, and it may be concluded, therefore, that the retrograde movements of the colon are an important factor in its filling. While the colon is full the appendix may be seen to fill and empty several times. Emptying may be retarded, and it may retain opaque matter long after the colon is evacuated.

Hurst believes that the appendix may be shown in half of all persons examined. The presence of adhesions may be determined. To show concretions the patient should be rayed before giving the meal. Chronic appendicitis, he insists, is one of the most common causes of enterospasm, the colon often being narrowed and spastic in places.

For examination of the appendix, Imboden places the patient in a horizontal position with the tube under the table and the fluoroscopic screen on the abdomen. Means of palpation are most essential; Imboden prefers using the gloved hand and a 10 cm. gauze bandage-roll. The vertical and Trendelenburg positions should also be used in determining fixation. Far more appendices can be visualized by the opaque meal than by the enema. Other points which he mentions are as follows: The pathologic effects of inflammation of the appendix are peritoneal adhesions, obliteration or strictures of the lumen, and the presence of concretions. The last of these can be occasionally demonstrated by the x-ray, and the other three conditions may sometimes be inferred from the following manifestations: Drainage, position and direction, kinks or obliteration, size, length and caliber, mobility and points of tenderness. The mere presence of some of the opaque meal in the appendix is no indication of chronic disease. Delay in emptying beyond twenty-four hours after the cecum is empty, or after vigorous catharsis, or if delayed emptying is associated with a distinct area of tenderness, is to be regarded with suspicion. Chronic disease is not dependent upon the position of the appendix but is more often found in the following positions: Posterior and external to the cecum with the distal end directed upward and meeting within the peritoneal cavity; posterior and external to the cecum, without the peritoneal cavity, and directly behind the cecum, often just behind

the ileocolic valve. A tender area located in the course of the appendix must always be regarded as very suspicious.

Spriggs and Marxer,[11] in an important article, describe in detail 36 cases in which the radiographic and operative findings were compared. In all of these the diagnosis was verified at operation. These writers prefer an opaque meal of buttermilk and barium sulphate after preparation of the patient with castor oil. Their observations proved that the normal appendix fills and empties about the same time as the cecum.

Fig. 585.—Filling-defect, F, D, corresponding to a palpable tumor. At operation a large retrocecal abscess was found.

The best view is usually obtained about twelve to fourteen hours after the opaque meal. In determining whether the appendix is or has been diseased they paid a great deal of attention to filling and emptying, shape, mobility, position, hyperactivity, spasm, tenderness and the presence of concretions. It would seem from their experience that great reliance can be placed on this method of diagnosis.

Recapitulating the signs of appendicitis as noted by the foregoing observers, the list comprises:

1. Shadows of concretions in the appendix.
2. Kinking.
3. Malposition.
4. Adhesions about the appendix and cecum.
5. Retention of barium in the appendix.

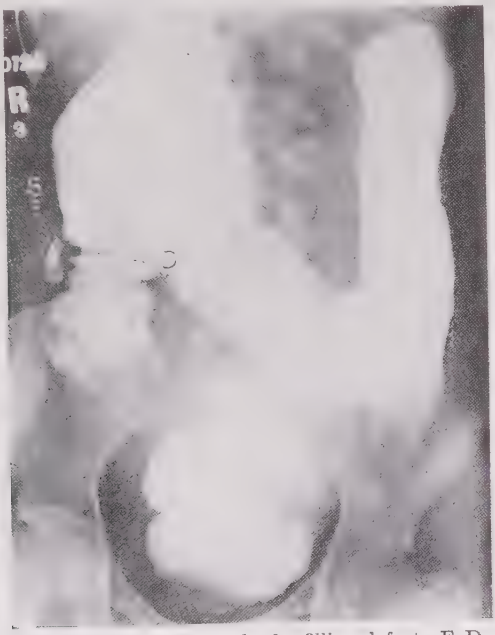

FIG. 586.—Cecum narrowed and irregular by filling-defects, F, D. To the outer side of the contracted cecum is the shadow of a fecalith, S, immediately above it is a small collection of barium. At operation the concretion was found to be about 2 cm. in diameter and lying at the bottom of a discharging sinus, which communicated with a post-appendiceal abscess.

6. Ileal stasis.
7. Insufficiency of Bauhin's valve.
8. Spasticity of the colon.
9. Pressure-tender point related to the appendix.

These offer a wide selection of sign-combinations according to the preference of the examiner. Some of them are quite plausible, and with more extended observations the roentgen diagnosis of chronic appendicitis may carry conviction. At

present, however, certain reservations seem to be warranted. Fecaliths are not often sufficiently dense to be demonstrable by the x-ray, but occasionally these, as well as gall-stones and other foreign bodies will be revealed, and by using the enema or meal their intra-appendiceal situation may sometimes be determined, or their differentiation from ureteral calculi, phleboliths, or calcified glands may be thus assisted. Permanently kinked appen-

FIG. 587.—Cecum, C, distorted by adhesions from a chronic appendicitis.

dices, may perhaps be pathologic; likewise permanent malpositions, especially the retrocecal, suggest pathology. In this connection, however, Cohn's statement that the appendix tends to change its position and configuration must be considered. Definite fixation of the appendix or of the cecum may, of course, be attributed to inflammatory adhesions; but findings in this respect are often illusive. Whenever barium or bismuth enters the appendix, the length of time it may be retained there, within normal limits, is problematic; Cohn asserts that the appendix fills and empties intermittently as long as the meal remains in

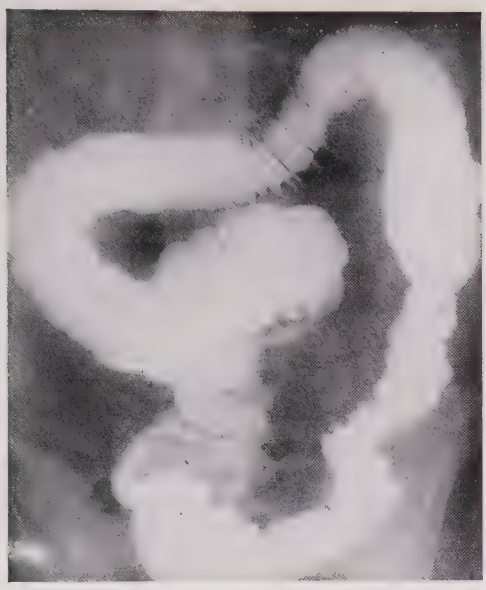

FIG. 588.—Cecum displaced upward and to the left by an old abscess of the appendix.

FIG. 589.—Barium-filled appendix, A, tender to palpation and not freely movable. At operation the appendix was found to be large and adherent. A Meckel's diverticulum 8 cm. long, situated 60 cm. above the ileocecal valve, was also found.

the cecum. Mere visualization of the appendix is not evidence of appendicitis; since chronic appendicitis tends to an oblitera-

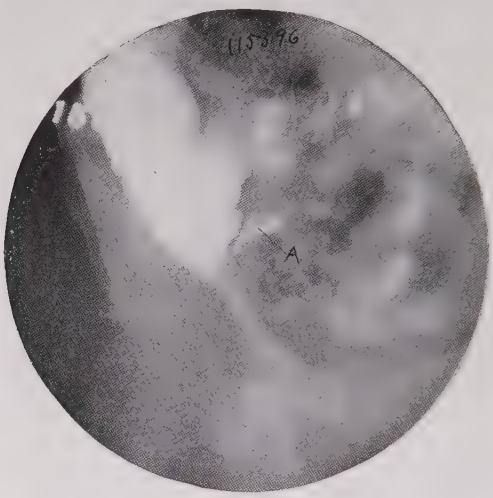

FIG. 590.—Barium-filled appendix, A. Fecal concretions were found in the appendix at operation.

FIG. 591.—Barium-filled appendix marked by arrow. Concretions found at operation.

tion of the lumen, failure to visualize the appendix should be the more suggestive. Just when chronic appendicitis can be inferred

from the presence of ileal stasis is not stated by the authors cited, and ileal stasis undoubtedly has other causes also. Insufficiency of the ileocolic valve, as demonstrated by the enema, has been meaningless in our experience. Spasticity of the colon

Fig. 592.

Fig. 593.

Fig. 594.

Fig. 595.

Figs. 592, 593, 594, 595.—Visualized appendices. No operation.

has other causes besides appendicitis. Pressure-pain points over the visualized appendix, or in close relation to the visualized cecum, are more significant than the clinical sign of tenderness

at the McBurney point. Without this tenderness all the other signs enumerated lose much of their persuasiveness.

Many patients sent for roentgen examination have symptoms suggesting a lesion either of the stomach, duodenum, gall-bladder or appendix, but with suspicion equally divided When by the roentgen examination the stomach and duodenum may reasonably be excluded, the x-ray has given its most valuable service and should not as yet be expected to go much further.

FIG. 596.—Chronic appendicitis found at operation. No evidence in the roentgen examination.

In fortunate instances the ray may positively convict the gall-bladder; or the combined clinical and roentgen findings may favor either the gall-bladder or the appendix, but at present often only surgical exploration can decide between them justly.

On the whole, the value of the roentgen signs of appendicitis appears to depend not only upon the intensity of the examiner's endeavor, but also, to some extent, upon the degree of his enthusiasm. Inasmuch as few normal appendices have been

found by surgeons or pathologists, the diagnosis of appendicitis upon any grounds whatever is not at all hazardous, but the novice should make sure that the appendix has not previously been removed, lest he mistake barium in the ileum for a shadowed appendix and draw his conclusions accordingly.

My own observations have included cases of retrocecal abscess, probably of appendiceal origin (Fig. 585), fistulous abscess with shadowed concretion (Fig. 586), distortion of the cecum by

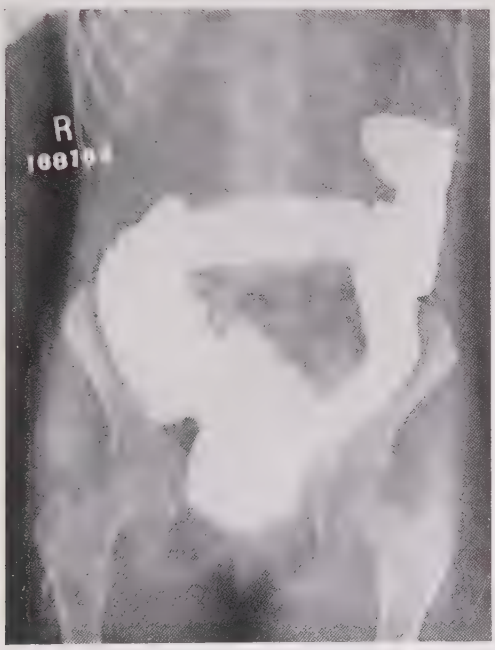

Fig. 597.—Chronic appendicitis found at operation. Roentgen examination negative.

adhesions from a chronic appendicitis (Fig. 587), and displacement of the cecum upward and to the left as a result of an old abscess of the appendix (Fig. 588). While the roentgen evidence in these cases was strongly indicative of a lesion, it was not alone decisive as to the nature of the process, except in the case with a fecal concretion. Spasticity of the distal colon, in cases which operation proved to be chronic appendicitis, was noted sufficiently often to occasion remark, but, while interesting, this could

not be considered diagnostic. In a small percentage of the colons examined, the appendix was visualized by the enema.

Fig. 598.—Old appendiceal abscess.

Fig. 599.—Chronic appendicitis.

Some of these cases went to operation and a chronic appendicitis was found (Fig. 589); in a few instances the appendix contained

FIG. 600.—Normal appendix.

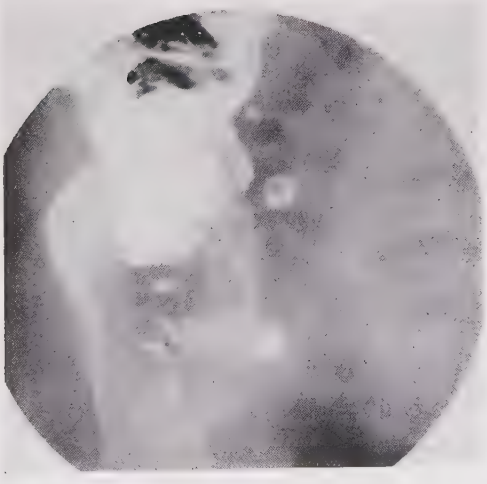

FIG. 601.—Normal appendix.

fecaliths, but the roentgenogram did not show their presence (Figs. 590 and 591). Unoperated cases with a visualized appendix are illustrated in Figs. 592, 593, 594 and 595. In a large series of patients operated on for chronic appendicitis the roentgen examination after the opaque meal was negative (Figs. 596 and 597).

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CHAPTER XXIX

MISCELLANEOUS LESIONS AND CONDITIONS OF THE COLON

Polyposis.—Relatively few cases of extensive polyposis of the colon have been recorded. Doering[1] in 1907, collected 52 cases, including 2 of his own. Recently Soper[2] has collected 8 additional cases and reports 1 personally observed. Soper's case was examined by the x-ray after colectomy, but no mention is

Fig. 602.—Polyposis of the colon showing obstruction to the enema.

made of a roentgen examination in any of the other cases available for reference.

Of the recent cases seen in the Mayo Clinic, one was submitted to roentgen inspection. The patient, a man aged 30, had had diarrhea for a year, with abdominal pain and distress. A tender, freely movable, sausage-shaped mass could be palpated in the epigastrium. The proctoscopic examination revealed a generalized mucosal inflammation, becoming granular higher up. The stools contained pus and red blood cells, but no parasites.

The two roentgenograms herewith show the condition as seen by the x-ray. The first examination (Fig. 602) showed apparent obstruction in the pelvic colon. At the second examination the entire colon was filled but was irregularly mottled throughout, and this was doubtless due to the multiple papillomatous growths (Fig. 603).

At operation the colon, from the hepatic flexure on, showed marked thickening of its walls, and the vessels were injected. An ileostomy was made. Four and a half months later, the

Fig. 603.—Polyposis of the colon.

patient having gained weight and strength, a second operation was performed. This time a colectomy, complete, save for about 30 cm. of sigmoid and rectum, was done. The exsected bowel was found to contain multiple polyps, beginning in the ascending colon and extending to the middle of the sigmoid.

Figure 604 is the photograph of a specimen from the colon in a similar case of polyposis.

Anomalies of Migration and Rotation.—Connell[3] points out that in its normal development the ileocecal juncture migrates

from below upward and to the left to form the splenic flexure, crosses the abdomen to the hepatic flexure where it rotates on its long axis, descends, and is fixed in its usual location in the right iliac fossa. This complicated embryologic maneuver is generally spoken of as "rotation of the cecum," but Connell shows that it comprises three distinct elements, viz., migration, rotation, and fixation. By migration, he means the journey of the

Fig. 604.—Photograph of specimen from colon. Polyposis.

ileocecal juncture up the left side, across, and down the right side of the abdominal cavity. Rotation should be confined to the actual axial rotation of the ileocecal juncture through an angle of 180 degrees. Fixation means the blending of the posterior colonic peritoneum with the prerenal parietal peritoneum.

Migration, he states, may be incomplete or delayed. The commonest arrest of migration occurs at some point between

the hepatic flexure and the usual location of the cecum in the right iliac fossa. It may occur at the hepatic flexure, or distal to it, either before or after fixation. If it occurs before fixation, the cecum may fall back to the left iliac fossa. This is unusual, but may account for cases of left-sided appendicitis in which the viscera are not transposed. With delayed migration the cecum may be in its normal position, but adventitious bands or membranes may suggest that fixation began before migration was complete.

FIG. 605.—High cecum. Possible arrest of migration. No operation.

Non-rotation may occur with incomplete migration before the development of the hepatic flexure, or, less frequently, it may persist after formation of the hepatic flexure and ascending colon. In these instances the terminal ileum enters the cecum from behind or from the right side. With excessive rotation, which may be even as much as 270 degrees, the ileum enters the cecum in front.

Fixation may be absent, or excessive, or improper surfaces may be fused. The cecum mobile is due to an absence of fixation. Connell suggests that the Lane kink may be the result

of anomalous fixation, while Jackson's pericolic membrane may be due to anomalous fixation, excessive rotation, or delayed migration.

Apart from the question of Lane's kink and Jackson's membrane, I have encountered occasional instances of incomplete migration. Now and then I have noted a high placed cecum with a very short ascending colon, due perhaps to incomplete migration (Figs. 605 and 606). Less often, the arrest of migra-

Fig. 606.—High placed cecum. Possible arrest of migration. No operation.

tion is strikingly evident, as in Fig. 607. In Fig. 608 the cecum is fixed at the site ordinarily occupied by the hepatic flexure.

Cecum Mobile.—In 1908, Wilms[4] announced his theory that in many cases of so-called chronic appendicitis the real cause of the pain and tenderness at McBurney's point was a long, movable cecum. The pain, he suggested, was produced by twisting and stretching of the nerves in the mesentery, and this accounted for the failure of appendicectomy to relieve the symptoms. Wilms, therefore, advised fixation of the cecum also, and reported satisfactory results in about 40 cases. Since his contribution,

cecum mobile has been frequently discussed by others, being either indorsed or disputed as a disease-entity. Case[5] states that it is easily recognizable roentgenologically. Associated with abnormal mobility, varying degrees of dilatation and elongation, there is stasis in the cecum long after the remainder of the colon has been emptied. Great tenderness is often elicited by palpation over the cecal shadow. He goes on to say that this dilated, elongated cecum is not always mobile, being often asso-

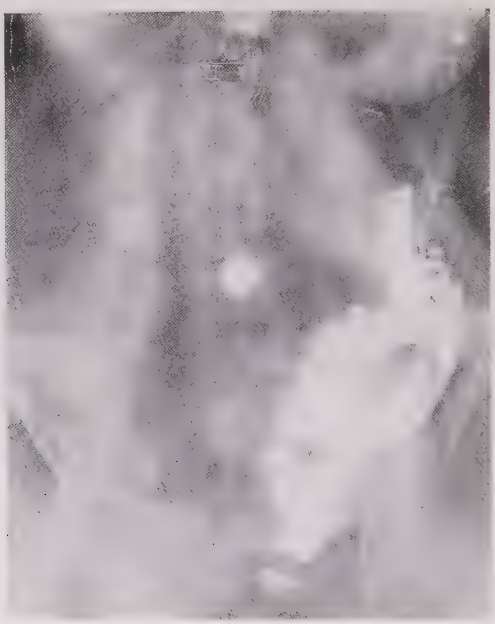

FIG. 607.—Non-migration of colon. Plate made twenty-four hours after ingested meal (Dr. J. H. Selby). The colon is almost completely visualized and lies entirely to the left of the spine. The arrows indicate the flexures. Confirmed by operation.

ciated with adhesions. Hausmann[6] discusses the subject exhaustively, and gives the roentgenograms of several cases, showing extraordinary mobility of the cecum. Béclère and Mériel[7] say that abnormal mobility of the cecum, which has been called cecum mobile by analogy to abnormal displacement of the kidney, is not really a morbid condition. It is compatible with perfect health, and appears only to be a mechanical condition capable in association with other causes, of favoring the develop-

ment of certain functional troubles. While its radiologic study is of interest, they say, the findings obtained are never sufficient to recommend operative intervention. Schwarz[8] mentions a case in which he could demonstrate that the cecum, with its abnormally wide and therefore readily filled appendix, moved about 5 cm. toward the median line when the patient was placed in the lateral position. He considers this to be what Wilms would call cecum mobile.

FIG. 608.—Cecum fixed high up in right abdomen, due probably to incomplete migration. No operation.

Jackson's Membrane.—Jackson,[9] in 1909, described a series of cases in which the proximal portion of the colon was closely invested with a delicate, transparent, vascular membrane or veil, somewhat resembling the arachnoid, or a thin pterygium. Usually the cecum was not involved, and the membrane extended from the cecum toward or up to the hepatic flexure; in one instance it passed across to the transverse colon which was drawn down parallel with the ascending colon. In advanced

and characteristic cases it seems to bind the colon close to the abdominal wall, producing marked angulations of the colon, or a practical stricture of its lumen. The clinical sydrome includes pain referred to the whole right abdomen, general right-sided tenderness, though frequently more marked at McBurney's point and just below the ribs, constipation, mucus in the stools, gas distention, loss of weight, gastric fermentation, and neurasthenia. Often appendicectomy or cholecystotomy has been done without relief. In a few instances Jackson has removed the membrane by careful dissection, with good results.

Skinner[10] has discussed the roentgen manifestations of Jackson's membrane, both in theory and practice. He states that there are two favorite sites upon the ascending colon for pericolic bands: First, just below the hepatic flexure, on the ascending colon. This almost seems to be an accentuation of the normal mesenteric attachment. It produces a filling-defect in the form of a circular constriction of the colon, which causes a partial damming back of the colonic contents, with tenderness along this portion of the colon. Second, a frequent pericolic band seems to constrict the ascending colon upon a level with the ileocecal valve, producing a transverse, linear filling-defect, and this is usually accompanied by ileal adhesions causing stasis. He also shows the roentgenogram of a case of pericolitis dextra, in which the cecum lies in the true pelvis and is loaded with bismuth; the ascending colon is narrow, spastic and poorly filled; the hepatic flexure is high, and stringy mucous shadows are seen in the transverse colon. Skinner is careful to point out numerous possible sources of error in interpretation, especially spasm, and says: "The disposition to take roentgenograms of the abdominal viscera at their face value is extremely dangerous, as there is probably nothing which lends itself so easily to interpretations of thought."

Transposition.—Transposition of the colon is an interesting feature of the rare cases of *situs viscerum inversus totalis*, and a few cases have been reported by roentgen observers. Transpo-

sition of the colon may exist also without transposition of the other viscera (Fig. 609).

Intussusception.—Two cases of intussusception in which a roentgen examination was made have been noted in the literature. One case reported by Lehmann[11] was that of an eighteen-year-old patient. Upon introducing the enema it flowed without interruption to about the middle of the transverse colon. Here it

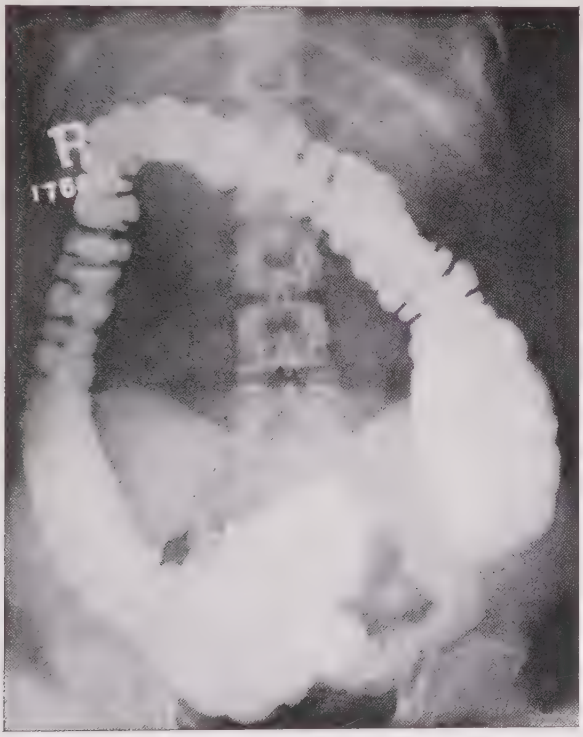

Fig. 609.—Transposition of the colon, which is otherwise normal. Confirmed by careful screen examination. The stomach was not transposed, nor was the heart.

was definitely obstructed, and, after a little, the stream sent out a projection about 1 cm. broad along the upper and lower borders of the transverse, beyond the obstruction, and between these projections was an area of lessened density occupied by the invaginated small bowel. The invagination corresponded exactly to the roentgen findings.

The other case, recorded by Groedel,[12] was of a boy 7 years of age. With the enema the colon was visualized throughout and there was a slight retrograde filling of the ileum, but nothing distinctive was seen. Two days later an opaque meal was given. Eight hours afterward some of it had passed into the colon, but the terminal ileum was markedly dilated, and

FIG. 610.—Actinomycosis of the cecocolon. Filling defect at *a*. Bauhin's valve incompetent.

Groedel considered the picture typical of ileocecal stenosis. At operation 15 cm. of the bowel was found to be invaginated.

Actinomycosis.—The following is a case history of actinomycosis.

Case 278,991, a man, aged 42, came to clinic July 15, 1919, giving a history of having had, one year before, soreness across the lower abdomen, more severe on the right side, which lasted one month. He was constipated, but had no diarrhea. This disturbance dis-

appeared until May 1, 1919. Similar attacks, pain more severe at night, caused unconsciousness. He partially recovered from this but had occasional pain in the right side and hip. An exploratory operation was done elsewhere June 17, 1919, and a mass was found in the right lower abdomen but was not removed. The patient had lost 20 pounds in two or three months.

A roentgenologic diagnosis was made of a negative stomach and a filling defect in the cecum and ascending colon (Fig. 610). At operation many adhesions were found (of the small intestine and omentum) in the region of the cecum which was indurated and bound down to the posterior and right lateral abdominal walls, forming a mass the size of a doubled fist. The pathologist reported actinomycosis of the cecum and appendix.

FIG. 611.—Megasigmoid. The sigmoid was found at operation to be thin-walled and enormously distended.

Hirschsprung's Disease (Megacolon) and Megasigmoid.—Congenital idiopathic dilatation of the colon is easily shown by the x-ray, and several observations have been published. A typical case is that reported by Linde and Kleiner.[13] The child, a girl 3½ years of age, was extremely constipated from birth, and had never had a bowel movement without an enema. The abdomen was protuberant. The roentgenogram of the enema-filled bowel shows the entire colon to be excessively

broad and capacious and with very little haustration. Elongation with dilatation of the sigmoid (megasigmoid) appears to be more frequent than the complete dilatation of Hirschsprung (Béclère and Mériel).[14] Figure 611 is the roentgenogram of a case.

Fig. 612.—Case 204,369. Female, aged 21. Congenital megacolon. Confirmed by necropsy.

Incompetence of The Ileocecal Valve.—Insufficiency of Bauhin's valve, permitting a retrogression of the cecal contents into the small intestine, has been given considerable attention from the roentgenologic viewpoint by Case,[15] Dietlen,[16] Groedel[17] and others.

Case, who began his observations in 1910, has found the valve to be incompetent in about one-sixth of all cases examined with the enema. He uses an enema, made up with either barium or bismuth, which is warmed to a temperature of 100° F., and the container is held not higher than 60 cm. above the patient. For the most part, the patients examined were suffering from gastro-

intestinal symptoms and complained of constipation. In many cases he has also observed a reflux of ingested bismuth from the colon into the ileum. Case believes that incompetence of the valve is a significant abnormality, and that it is a common cause of ileal stasis.

Dietlen avows his belief that, while the valve is incompetent in infants, it is normally competent in children and adults. He has been able to demonstrate insufficiency, usually by the enema but occasionally by the ingested meal, in a number of cases. Few of these patients were operated upon, but there were clinical or roentgenologic signs of various pathologic conditions such as chronic appendicitis, dilatation of the cecum, colitis, extrinsic tumors, perityphlitis with adhesions, obstipation and perichole-cystitis. In one or two of his cases the colon was presumably normal.

In studying the ileocolic valve, Groedel uses 1 liter of an enema containing 300 gm. each of barium sulphate and bolus alba. After introducing the enema the patient is allowed to empty the bowel partially by natural defecation without unusual effort. After this, if a large portion of the small bowel is retrogradely filled, a pathologic condition of Bauhin's valve may be assumed. In the majority of cases, he states, the cause is either a chronic catarrhal affection of the cecum, or a chronic perityphlitic process. Other causes include anatomic anomalies, nervous disturbances, dilatation of the ascending colon, ulcers and tumors of the valve-ring, cecum or cecal region.

Singer and Holzknecht[18] noted incompetence of the valve in numerous cases of obstipation, and this occurred whether the cecum was dilated or not.

The theory that the ileocolic valve is normally competent is supported by some of the anatomic and experimental studies which have been made. The work of Keith[19] has been adduced in corroboration. A recent monograph by Rutherford[20] also substantiates this view.

Contrary opinions regarding the competence of the valve and the significance of the incompetence shown by the x-ray have

been advanced by numerous authorities. Some of these are frankly cited by Dietlen and Case. Relative to the matter of giving nutrient enemata, it has been shown that, at least in certain cases, the valve permits the entry of an enema into the ileum. Senn[21] found by experiment that air at a pressure of ¼ to 1½ pounds would overcome the resistance of the valve, and thinks that this incompetency is caused by a lateral and longitudinal distention of the cecum which mechanically separates the margins of the valve. Hurst[22] declares unequivocally that the ileocecal sphincter does not prevent regurgitation into the ileum, as, in common with other observers, he has seen a bismuth suspension pass into the ileum when run into the colon at a pressure as low as 1 foot of water. There can be no doubt, he says, that the function of the valve sphincter is, as Keith originally suggested, to prevent the contents of the ileum passing too rapidly into the cecum.

In my own work, with the enema given in the manner described, the clysma enters the ileum in the great majority of cases —probably nine-tenths of them. The patients examined are of the character usually sent for the roentgen test; most of them have gastro-intestinal symptoms of some sort, and many are constipated, but there is also a considerable number whose symptoms are found at operation to be due to various abdominal lesions not involving the bowel, which is normal. The incompetence is of all degrees, ranging from a trivial backflow through the valve to an extensive filling of the lower ileum (Figs. 613, 614, 615 and 616). Absolutely no relation has been noted between this insufficiency and pathologic conditions, either in general or in particular.

In the course of abdominal operations for various conditions, the late Dr. E. H. Beckman (Mayo Clinic) carefully examined the ileocecal region in two hundred cases which had shown incompetence of the valve with the opaque enema, but he found no anatomic abnormality to account for it.

It is doubtful whether an enema, put into the bowel under unphysiologic conditions, and necessitating at least a slight

degree of hydrostatic pressure, would be a fair test of the physiologic competence of the valve. A regurgitation of the in-

FIG. 613.

FIG. 614.

FIG. 615.

FIG. 616.

FIGS. 613, 614, 615, 616.—Barium in ileum from enema.

gested meal into the ileum, after once passing the valve, would theoretically have greater import. But whether this indicates merely an unimportant perversion or laxity of function,

or is significant of serious pathology, with possibilities in the way of differential diagnosis, remains to be determined.

Enteroliths.—Besides the occasional presence of fecal concretions in the appendix, as mentioned under the latter subject, enteroliths of larger dimensions are sometimes discovered in the intestine. Pfahler and Stamm[23] report a case in which the x-ray examination revealed an abnormal mass, 4 cm. in diameter, of slight opacity, occupying the pelvic, then the iliac region. Injection of the colon with an opaque enema showed definitely that the mass was in the cecum; it could be moved

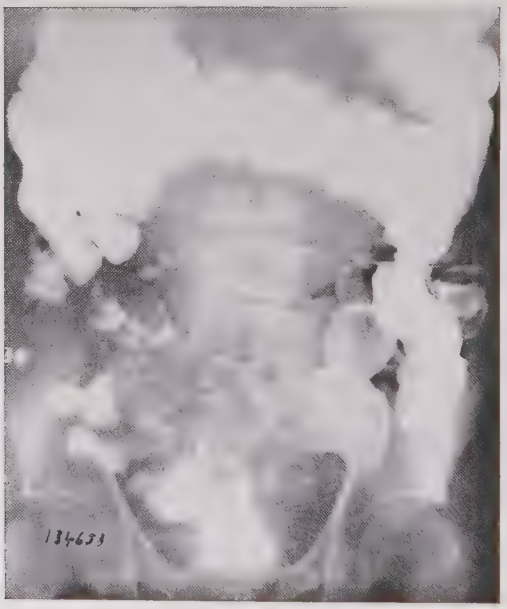

FIG. 617.—Barium-coated scybalæ in lower bowel resembling concretions.

about within the cecum and ascending colon. It was partially dissolved by glycerin enemas, passed into the rectum, and was there broken up with the finger and removed. It proved to be a fecalith consisting mainly of magnesium phosphate. In Fig. 617 the barium-covered scybalæ resemble concretions.

Foreign Bodies.—The approximate localization of foreign bodies in the intestine is sometimes a matter of importance.

For example, when anastomosis has been made with a Murphy button and the exit of the button is delayed, it is desirable to know whether it has passed into the colon or not. This can be done conveniently by giving an opaque clysma and noting whether or not the shadow of the button is enveloped in that of the enema. The method is applicable, of course, in the case of any opaque foreign body.

Figures 618 and 619 illustrate a case in which a dental plate in the transverse colon was localized by an enema.

Fistulæ.—Following operations on the intestine or as a result of disease, external fistulæ sometimes develop, and it may be desirable to know the exact part of the bowel in which they originate, as well as the extent of their ramifications. Ordinarily this can be learned by injecting the fistula with a bismuth-petrolatum paste. The paste may enter the bowel in sufficient quantity to visualize a segment of it, and thus show the point of communication (Fig. 620); if not, the colon may also be filled with an opaque enema.

In occasional instances it may be doubtful whether or not a suppurating sinus following an abdominal operation has any connection with the bowel. In such cases we have made effective use of a procedure suggested by E. S. Judd. The sinus is thoroughly injected with the paste, the external opening is sealed with gauze and adhesive plaster, and a roentgenogram is made. A second roentgenogram is taken twenty-four hours later, after purging the patient with oil. If the second plate indicates a diminution of the paste, as shown by changes in the sinus-shadow, it is safe to assume that a fistulous connection with the bowel exists; otherwise not.

Fig. 621 illustrates an interesting post-operative condition. Following an operation on the left kidney fifteen years ago the patient developed a suppurating sinus which has continued ever since. An attempt to close it by operation ten years ago failed. Both these operations were done elsewhere. Another attempt was made here in November, 1916. During this latter operation a small amount of a solution of methylene blue was

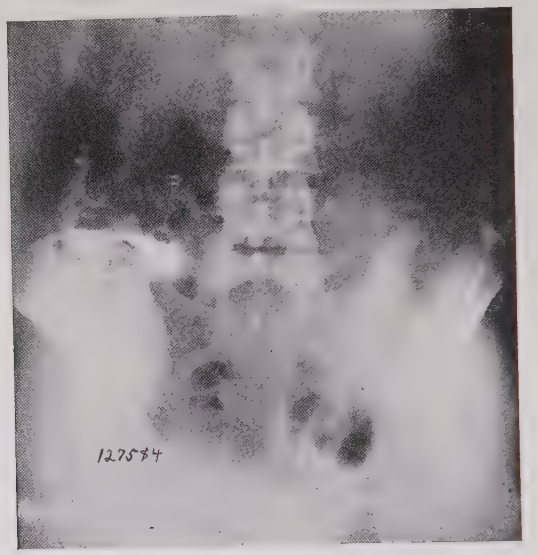

FIG. 618.—Dental plate, P, in bowel. Location uncertain.

FIG. 619.—Same case as in 618, twenty-four hours later. The enema locates the plate, P, in the transverse colon. Subsequently, the plate was passed in the stool.

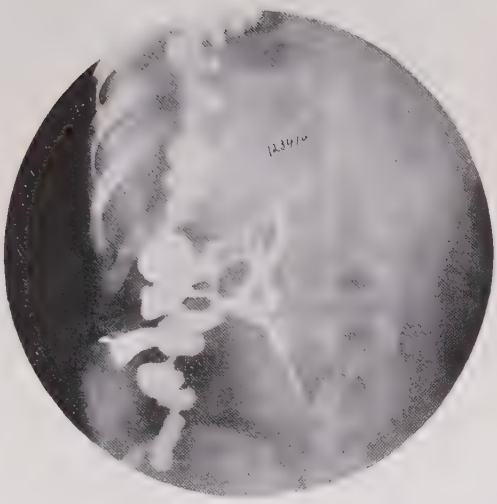

Fig. 620.—Fecal fistula injected with thick barium-pap, showing its ramifications and point of communication with the colon.

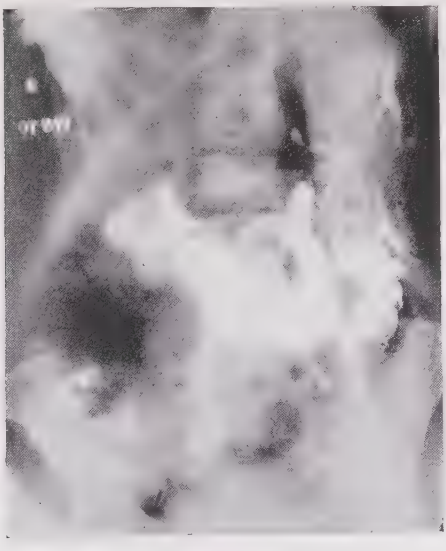

Fig. 621.

injected into the fistula, and some of it immediately appeared in the patient's mouth. Because of insuperable difficulties the operation was abandoned and treatment with Beck's paste was directed. After the first injection of the paste, the patient was sent for roentgen examination. The roentgenogram (Fig. 621) shows the extensive sinus ramifications. Some of the paste has entered the colon and the stomach is completely filled by it.

Rectum.—Direct inspection of the rectum through the proctoscope is, under ordinary circumstances, so far superior to other methods of examination that the aid of the x-ray is rarely called for. Occasionally, however, in the case of a rectal cancer, more explicit information is desired as to the upper limit of involvement, and this is obtainable by the roentgen examination. An instance is shown in Fig. 622. An interesting case was observed in which a fecalith obstructing the upper rectum was first detected by the x-ray (Fig. 623); no digital examination having been made.

The Colon after Operation.—When there are clinical indications of acute intestinal obstruction following laparotomy, the question arises as to the fact of obstruction and its probable site, and exceptionally a roentgen examination may be permissible. In some such instances Case[24] has found it unnecessary to administer any opaque material, roentgen observations being made possible by the gas-distention of the intestine. With acute colonic obstruction the haustral markings and the distribution of the gas were sufficient to identify the colon, while in acute obstruction of the small bowel its serrated contour and the parallel arrangement of its coils were equally characteristic. When circumstances allow the administration of a barium meal or enema the diagnosis can be made with greater certainty.

Recurring cancer of the colon, after resection of the original growth, can, of course, be shown by the x-ray. Numerous short-circuiting operations such as ileo-sigmoidostomy and ceco-sigmoidostomy are being performed, not only for the palliation of otherwise inoperable conditions, but also for stasis.

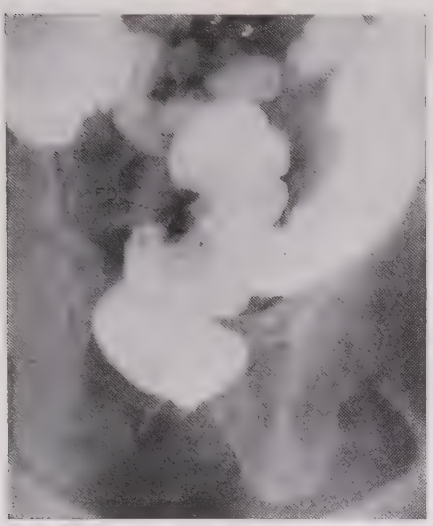

FIG. 622.—Cancer of upper rectum. Filling-defect, F. D.

FIG. 623.—Large fecalith, F, in rectum. Patient aged two years.

After any of these the functional results can be studied by the x-ray, frequently with profit and always with interest. Roentgen observers agree without exception that after any anastomosis which leaves a blind sac of the colon proximal to the point of juncture, the sac tends to fill by a retrograde movement of the ingested meal, which may remain there for long periods.

FIG. 624.—Case 201,035, a man, aged 23. *Roentgen examination July* 12, 1917. x-ray of the colon showed a filling-defect of the rectosigmoid juncture, and a tumor thought to be extrinsic. At operation the rectum was dilated and about 1 liter of hard feces impacted in the upper rectum and sigmoid were removed by means of placental forceps and irrigation. Later a Mikulicz operation was done for Hirschsprung's disease of the colon. The sigmoid and upper rectum were enormously distended. The colon was thin-walled and about 15 cm. in diameter.

Among the interesting post-operative cases which have been examined was a patient who had a five-year history of abdominal discomfort and gas-distention. Four years ago her appendix was removed, without relief. Sixteen months ago an ileosigmoidostomy was done, but the results were disappointing. At this clinic the right half of the colon was resected and some improvement in the patient's condition resulted, but she still has some of her original symptoms. The roentgenogram (Fig.

FIG. 625.—Case 228,083. Male, aged 25. Filling-defect in the upper rectum and lower sigmoid. Diagnosis: Coprolith.

FIG. 626.—Colon after ileo-sigmoidostomy.

626) shows the barium-filled colon, prior to the last operation. The enema divided at the point of anastomosis; part of it entering the ileum, the loops of which can be seen, and the other stream passed up through the sigmoid and descending colon. The two streams met at the hepatic flexure.

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CHAPTER XXX

PNEUMOPERITONEAL DIAGNOSIS

The introduction of air or gas into cavities of the body as an aid to diagnosis is not new for it has been employed in the pleura, joints, urinary bladder, kidney pelvis, ventricles of the brain, etc., but its use in many of these locations has been largely discontinued. What would seem to be an adaptation of the above method to the abdominal cavity and which forms one of the most spectacular methods of modern diagnosis is the roentgen examination of the solid viscera of the air or oxygen inflated peritoneal cavity. This method has been given considerable impetus during the last seven years through the work of Lorey, Weber, Meyer-Betz, and others in Germany, and Stein and Stewart and Orndoff in America.

Two distinct stages in the development of the pneumoperitoneal method can be differentiated. The first stage consisted of inflation of the abdominal cavity and subsequent examination by the aid of an endoscope or cystoscope and is representative of the work of Kelling and Jacobaeus. The second stage began with the work of Lorey who was the first to apply the roentgen-ray to pneumoperitoneum in a case of hepatic cirrhosis. Since that time numerous authors have written on the subject, notably Rautenberg and Goetze.

A chronologic sketch of the literature on pneumoperitoneal diagnosis follows:

The abdominal viscera were first studied after filtered air inflation by means of a small Nitze cystoscope by Kelling,[9] who in 1902, experimentally demonstrated what he termed celioscopy in a dog, showing some abdominal organs. He prophesied the application of such a method of examination in the diagnosis of disease in the abdominal cavity.

The next article on the subject to appear in the literature was by Jacobaeus,[6] in October, 1910, who demonstrated the possibility of cystoscopic investigation (laparoscopy) of the serous cavities. His plan was to puncture the abdominal wall after incision of the cocainized skin with a trocar corresponding in size to a No. 17 Charière catheter. Through this trocar, filtered air was pumped into the peritoneal cavity by means of an ordinary Politzer air pump and then a Nitze cystoscope (No. 14 Charière) was inserted. Provision was made to keep the trocar in place and also to prevent air from escaping through the cystoscope. In this way Jacobaeus was able to visualize the abdominal viscera in much the same manner as one may explore the urinary bladder with the cystoscope. After some experimental work on animals and dead (human) bodies Jacobaeus made clinical use of this method in 17 cases of ascites. He punctured the abdominal wall obliquely with a trocar, the ascitic fluid was withdrawn and air was pumped into the peritoneal cavity before the cystoscope was inserted. In one case he was able to diagnose cancer metastasis of the liver, in another high grade perihepatitis, and in still another carcinoma of the stomach; furthermore, he succeeded in observing peristalsis.

Kelling[10] published a second article in November, 1910. The purpose of this paper was to call Jacobaeus' attention to the fact that he had described the method in 1902 under the term celioscopy. At the time of writing, Kelling had viewed the human abdominal cavity by this method only twice, once in a patient with ascites and once in a patient with carcinoma of the stomach.

Laparoscopy was first used in this country by Bernheim[1] who reported 2 cases in June, 1911. He employed an ordinary proctoscope with a half-inch bore which served as a cystoscope. An electric headlight furnished the illumination. This instrument (without obturator) was introduced through an incision in the epigastrium of sufficient size to accommodate the proctoscope. Bernheim's first patient was a man deeply

jaundiced in whose abdomen a markedly distended gall-bladder could be palpated. The only abnormality noted was the distended gall-bladder. The tube was withdrawn and the incision enlarged for the usual exploratory laparotomy, which disclosed a carcinoma of the head of the pancreas. In Bernheim's second case, the cystoscope was brought into use in order to rule out, if possible, the presence of a gastric ulcer. This he succeeded in doing, the case proving to be one of chronic appendicitis. He did not state whether or not he used air inflation of the peritoneal cavity.

In a paper dated September 19, 1911, Jacobaeus[7] credits Kelling with having first described celioscopy (laparoscopy). Jacobaeus, on the other hand, believes that he himself is entitled to the practical application of the method, since he had reported the results of more than 100 of these examinations. His technic on the whole remains the same as that described in his preliminary article. He reports only one complication in 115 cases, namely a hemorrhage into the peritoneum from puncture into the abdominal wall following laparoscopy. Jacobaeus classified the following cases:

	Cases	Examinations
1. Cirrhosis of the liver and closely related cases	12	20
2. Syphilis of the liver	3	4
3. Diseases of the liver with Pick's aspect of disease	3	11
4. Tuberculous peritonitis	3	5
5. Abdominal tumors (cancer of the stomach, liver and peritoneum)	15	29
6. Cases of lesser interest	9	11
	45	80

A large proportion of these cases were, therefore, hepatic diseases. According to Jacobaeus, the diagnosis of cirrhosis was found to be simple when made by this method, except that peritoneal changes might be overlooked. The diagnosis in cases of Pick's syndrome was more difficult; little of practical value was learned from 3 cases of hepatic lues. The cases of tuberculous peritonitis had been fairly well established before

laparoscopy. Certainty as to cancerous characteristics was obtained in cases of abdominal tumors, some of which were in the stomach, some in the peritoneum and liver. In the cases of lesser interest there were no positive results and consequently the author did not discuss this group. Jacobaeus, while not wishing to overestimate his own work, was keenly aware of its possibilities. It now seems, however, that the diagnosis in many of the cases in which laparoscopy was done could have been made by a good clinician or surgeon without the aid of the cystoscope. A third article by Jacobaeus[8] in 1912 states the results of laparoscopy which he had been practising for one and one-half years; case histories and the results of examinations are given in detail.

In 1912, Lorey[12] reported a roentgenogram of a patient with cirrhosis of the liver on whom the Jacobaeus method of laparoscopy had previously been done. The air had not been withdrawn and ascites had again collected. Since Lorey could distinguish the contours of the liver and spleen and the presence of a tumor extending over their surfaces, he concluded that under certain conditions the inflation of air into the abdomen would be of diagnostic advantage. This is the first reported instance of the application of the roentgen-ray to pneumoperitoneum.

Weber,[27] in 1913, was really first to point out the value of oxygen-air inflation of the peritoneal cavity in connection with roentgenology. He demonstrated that many organs, tumors, and regions of the abdominal cavity, inaccessible to the ordinary methods of clinical and roentgen examination, might be recognized by this newer method of examination. After recording experimental work on animals and fresh human dead bodies he cited literature claiming that gas inflation of serous cavities is without danger, and expressed his preference for oxygen as it reduces to a minimum the danger of embolism. He believes that the rise occasioned in abdominal pressure is insignificant since the quantity of gas can be easily controlled, although care must be taken in its introduction because of the possibility of pressure on suppurative intra-abdominal areas. The danger

of injury to the abdominal organs had been completely obviated by the manner of inserting the trocar or needle, namely by a small incision down to the peritoneum in order to make the puncture through the unopened layers without danger. Weber concludes that nothing stands in the way of the application of this new diagnostic method in man when the diagnosis cannot be clearly made in other ways. He says that in combination with the Rieder method it produces particularly fine results. His experiments were made only with animals and on dead bodies of children.

Lorey[13] published a second article on the subject in February, 1914, in which he pointed out the technic and some of the dangers of the method. His technic consists in cocainization of the skin, and making a small incision 2 cm. long down to the peritoneum in the midline just below the umbilicus. The peritoneum is then punctured by a blunt needle. In this manner such dangers as puncture of the intestine or fatal embolism from puncture of a blood vessel are avoided.

It is a well known fact among roentgenologists that roentgenologic examination of the liver under ordinary conditions has not been entirely satisfactory. While this is the rule, one occasionally is able to see a very good outline of the liver and spleen, due to gas distention of the intestine. This suggested to Löffler[11] and others that gas inflation of the stomach and intestines might be employed in a roentgenologic study of the liver (including the gall-bladder), spleen, and left kidney. Although pronounced lesions of the stomach and intestines can also be shown in this manner, the results obtained are neither so accurate nor so safe as those achieved by the opaque meal method. The technic is comparatively simple. Löffler used from 1 to 1.5 liters of gas or ordinary air in the intestines. This was introduced through an intestinal tube by means of a simple rubber bellows or Politzer bulb. For inflation of the stomach he used effervescing salts. He believes that his method is adapted to earlier diagnosis than has heretofore been possible in showing the liver and spleen, gall-stones and enlargement of

the gall-bladder. The only contra-indication presented is severe inflammatory manifestations of the abdominal organs.

Meyer-Betz[14] in April, 1914, wrote with greater certainty. He states that the technic is simple if the patient has ascites; in this case the ascitic fluid is merely drawn off as completely as possible and about 2 liters of oxygen are slowly filtered through sterile cotton. In the absence of ascites it is best to incise the skin and abdominal wall down to the peritoneum which is then punctured by a needle having a short semicircular cutting point in order to avoid injury to the intestines. After inflation good pictures may be obtained of the liver, spleen, stomach, and intestines, especially if the hollow viscera are slightly inflated with gas. Meyer-Betz remarks that the gall-bladder itself is usually invisible. He believes that Riedel's lobe which may be confused with abdominal tumors can be easily recognized. Changes in the size of the liver can of course be judged roentgenologically; this is of diagnostic importance wherever palpation and percussion are of no avail. The method is of value if it is necessary to determine the boundaries of two neighboring organs, such as enlarged liver and spleen, or if tumors of the liver must be proved or disproved. It is a means of diagnosing adhesions of the upper surface of the liver to the diaphragm. It will give some information concerning changes in the form of the liver in lues hepatis, in cirrhosis of the liver, and in tumors of the surface of the liver. It would seem that it might be employed in a differential diagnosis of abscess of the liver and subphrenic abscess, but in so doing there is great danger of breaking up adhesions with the escape of pus into the general peritoneal cavity.

Rautenberg,[16] in June, 1914, reported on 5 cases of ascites. In one case he injected as much as 6 liters of oxgen after withdrawing the ascitic fluid. The patient was rayed in the standing and in the left lateral positions. Rautenberg's experience was practically the same as that of Meyer-Betz. In September, 1914, Rautenberg,[17] in a second paper, cites a wider experience with the pneumoperitoneal roentgen examination. He has

extended the method still further by examination of the patient not only in the upright and lateral, but also in the dorsal and Trendelenburg positions. He has had no untoward effects from the method. In 6 cases without ascites this method of diagnosis was accurate enough to prove that exploratory laparotomy could be avoided. His efforts to visualize the gall-bladder, however, had been unsatisfactory. In concluding, the author spoke of the wisdom of applying the air-inflation-roentgen method to patients without ascites, for he had learned to appreciate more and more the diagnostic value of the method. He considers the examination simple and harmless and believes it will become established in internal medicine. In a third paper, January, 1917, Rautenberg[18] states that the pneumoperitoneal roentgen method had advanced beyond the experimental stage; that it is not only applicable to disease with ascites after puncture, but also can be employed in cases in which there is no fluid. He has been able to diagnose cirrhosis of the liver, tumors of the liver and spleen, abdominal tumors, carcinosis of the peritoneum, etc. In this article he claims that the gall-bladder can often be distinctly seen.

Goetze,[4] in November, 1918, published the earliest extensive report on roentgen diagnosis by means of gas inflation of the peritoneal cavity; this had been presented in June, 1918 before the Verein der Aerzte in Halle.[3] The cardinal point of the new method he states is the manner of filling the peritoneum with oxygen without danger. The technic of inflation, the instruments designed by the author, the indications and contra-indications, positions for making screen observations, and plating are all described in this paper. Goetze prefers to puncture the abdominal wall in the left rectus from 3 to 5 cm. below the umbilicus or in the rectus just below the costal arch outside of hepatic dulness. He uses from 2 to 3 liters of oxygen with little discomfort to the patient. Since gas always accumulates at the highest point, emphasis must be placed on a suitable position of the patient for examination. The standing, dorsal, lateral, abdominal, knee-chest, and Trendelen-

burg positions are all used. Goetze, by this method of examination, has been able to demonstrate such lesions as hernia and relaxatio diaphragmatica; abdominal tumors of all sorts; small collections of fluid that could not be found by other methods of examination; adhesions, carcinomatosis, tuberculosis of the peritoneum and intestines; cirrhosis of the liver, nodular metastasis and echinococcus cyst of the liver; displacement, hydronephrosis, pyonephrosis, tuberculosis, tumors and stone of the kidney; size, shape, and position of tumors and adhesions of the spleen and of the accessory spleen. Important although still incomplete is the information obtained with regard to the gall-bladder. The diagnostic results of the illumination of the intestinal canal are not promising because of the crowding together of the intestine in the deepest part of the abdomen, thereby preventing the isolation of individual parts, and because meteorism which is commonly associated with intestinal diseases, makes puncture dangerous. With the patient in the Trendelenburg position, the condition of the uterus and adnexa, and of the urinary bladder, especially when the latter is simultaneously filled with gas, are distinguishable. The findings in each case were corroborated by operation. A few plates and many diagrammatic sketches illustrate this very valuable contribution which Goetze says is only an introduction to a detailed work to appear later.

Since the publication of Goetze's work, Decker[2] has also demonstrated the method, and Schmidt[25] has added his modification of Goetze's technic.

Rautenberg,[19] in a fourth paper, February, 1919, treated the subject at some length, reporting experiences which cover five years. He punctured the abdominal wall in the median line between the umbilicus and symphysis, or between the umbilicus and sternum; in patients with ascites he naturally chose the lowest point. Simultaneously with the introduction of an ordinary cannula gas was introduced. The cannula, 5 cm. in length, was introduced after sterilization and freezing of the skin. The quantity of gas injected varied, depending

on whether or not the patient had a firm or soft abdominal wall. Of course, it is understood that the stomach, intestines, and urinary bladder should be emptied before beginning the examination. Sterilization or filtration of the inflating air seems unnecessary. The patients were examined in the positions mentioned by Goetze. With little experience the difficulties of interpretation, which at first are very perplexing, are soon overcome. The tube distance, exposures, etc., are all matters of personal preference. The difficulty seems to lie in turning the patient so that the form, position, etc., of all the abdominal organs may be determined. The liver and spleen, the organs first distinguished by the earlier authors, have remained the easiest to orient; the gall-bladder may sometimes be discovered, but its condition cannot always be determined. Abdominal tumors, and stones in the kidneys are nearly always discernible. The pelvic organs, especially the female genitalia, and their changes, can often be recognized, but Rautenberg does not continue the use of this new method in diseases of the female pelvis, since the old palpatory examination seems to be more accurate in such cases. Twelve interesting case histories are given. Six are of diseases of the liver, 2 of cirrhosis, 1 of carcinoma, 1 of pseudoleukemia with enormous liver, 1 of acute atrophy, and 1 of echinococcus. One case of carcinoma of the peritoneum, 1 of tumor of the spleen, 1 of ovarian cyst, and 1 of tuberculosis of the right kidney, are given as illustrations of the efficacy of the method.

In February, 1919, Schmidt[25] related his experience with this method of examination. He refers to Goetze as the creator of the new method and states that it is of value in lesions in the vicinity of the diaphragm, liver, spleen, gall-bladder, kidneys, and female genitalia. The inflation of the stomach and colon may add to the value of these examinations. He introduced the method in his own clinic after witnessing the work of Goetze, except that he makes use of unfiltered air, instead of oxygen, which is later expelled by means of slight pressure on the abdominal wall. Occasionally he employs in addition Jacobaeus'

method of laparoscopy and finds it very valuable. Schmidt is enthusiastic about the method and finds it of great help in identifying obscure abdominal conditions.

Rautenberg,[20] in March, 1919, published a fifth paper on pneumoperitoneal roentgen diagnosis of the kidney. He spoke of his reasons for placing the patient in the lateral position when wishing to x-ray the kidneys, of the appearance of the normal kidneys, and of some of the abnormal conditions which he had succeeded in diagnosing.

In a second article Goetze[5] traces chronologically the literature on the subject. This was stimulated by Rautenberg's claim that he had invented the method of filling the abdominal cavity with air for the purpose of roentgen diagnosis. Goetze's articles would indicate that he has had by far the greater experience with this method and especially with patients without ascites. Goetze does not claim to be the inventor of pneumoperitoneal roentgen diagnosis, but to have done the decisive part of the work of creating the method.

Schittenhelm[24] has recently written a résumé of the work which was begun in his clinic by the late Meyer-Betz. He states that the procedure is often combined with inflation of the intestines, the contrast meal, introduction of the duodenal sound, etc. Schittenhelm, with Rautenberg, does not claim uniformly good results from plates of the gall-bladder. Gallstones are likely to be found only if they are rich in calcium and of an inflammatory nature. In detecting disease of the kidney, Schittenhelm, like Rautenberg, has found that the interpretation of the pictures is not always easy and is sometimes definitely cleared up only by operation.

Rautenberg[21] in a sixth paper, June 12, 1919, reported 4 cases of disease of the liver in which he believes that the diagnosis was made possible by pneumoperitoneum alone. He has been able to identify the outline of the gall-bladder to greater advantage in these cases than in any previously reported. In concluding Rautenberg states: "In no case should the physician practising internal medicine in a clinic neglect the opportunity

to utilize this method in connection with ascites puncture and to obtain roentgenograms of his patient in various positions of the body. The results will be dependent on what importance he attaches to roentgenograms in other diseases, that is, of what diagnostic help roentgenograms have been to him."

In a seventh paper published June 16, 1919 Rautenberg[22] describes in detail his latest technic. This has changed considerably during the last five years, but he considers it perfectly safe and of great simplicity. The patient is placed in the Trendelenburg position. After sterilization and cocainization of the skin a needle 4 cm. long and 1 mm. in diameter is slowly and perpendicularly inserted in the midline between the navel and symphysis while an assistant manipulates the bulb and the operator exerts a slight pressure on a second bulb with his left hand. At the moment the point of the needle reaches the peritoneal cavity the left hand feels the decreased pressure in the bulb and empties the latter completely by pressure. The assistant again manipulates the bulb and the development of pneumoperitoneum is indicated by the slowly increasing arch of the abdomen. The quantity of air introduced is judged by the inflation of the abdomen and by the subjective symptoms of the patient. In general the clearness of the view of the abdominal cavity is in proportion to the amount of air injected. It is surprising how little the patients complain, especially if a hypodermic injection of morphine has previously been made. The discomfort (shortness of breath, pain in the shoulders) is decidedly less in the Trendelenburg position. Another advantage lies in the fact that injury of the intestines by the point of the needle is less likely in this position since the intestines gravitate toward the diaphragm. After completion of the examination the air may be removed by re-inserting a slightly larger needle through the original puncture wound. The roentgen examination which is made in conjunction with the inflation consists primarily in a screen examination, which, if necessary, is followed by roentgenograms.

In this country, Stein and Stewart[26] tried out the pneumo-

peritoneal roentgen method, as advocated by the foregoing writers, with very satisfactory results. Their article contains many excellent illustrations, the interpretation of which had not been confirmed. In concluding the authors wish to have it understood that this procedure is not a competitor of the opaque meal method, for the latter concerns the hollow organs, whereas pneumoperitoneal roentgen diagnosis has to do with the solid abdominal organs.

Orndoff[15] in September, 1919 discussed briefly the technic employed in more than 100 cases of pneumoperitoneum. In his early cases he used air, later oxygen and nitrogen, but at present he prefers oxygen. The apparatus he employs consists of an oxygen tank, a water bottle indicator, a pressure gauge, needle, cotton filler, rubber tubing, glass connections, and so forth. Although the ordinary x-ray apparatus will suffice Orndoff believes that special equipment will greatly facilitate the work. The position of the patient is essential as it is necessary to have the gas in contact with the part, organ, or surface of the organ to be observed or roentgenographed.

The method of antiseptic preparation described consists in covering a small area of the skin with a solution of equal parts of lysol and glycerine. The application is facilitated by a small wooden applicator covered with lysol which serves to produce a pressure anesthesia that usually is sufficient.

In October, 1919 Rautenberg[23] again reviewed his work of the past five years, described his technic, and reported 14 cases of diseases of the liver, gall-bladder, peritoneum, spleen, ovary, and kidney. The identification of adhesions of the liver he considers much more accurate by pneumoperitoneum than by any general clinical examinations. In cases of gall-bladder disease, especially, pneumoperitoneum should not be resorted to unless other methods of examination have failed to give any diagnostic clue, for even those plates on which part of the gall-bladder is visible are of limited value. "The measure of the length and thickness of the right lobe is important for the liver, of the length and width for the kidneys, but only of the length for

the spleen, since the true thickness of the organ is uncertain when the patient is standing because of the diagonal position of the spleen." Rautenberg has learned from experience that the x-ray tube should always be kept at the same distance—60 cm. is suggested—from the patient in making plates of the peritoneum so that the actual measurement of the organs may be reckoned easily by taking into consideration the slight uniform magnification, which Rautenberg believes to be about $\frac{1}{10}$. The making of numbers of plates should gradually be replaced by fluoroscopic examination as the physician becomes more familiar with the customary displacement of organs and the interpretation of the relationships in the peritoneal cavity.

Technic.—The patient to be examined by the pneumoperitoneal method should be thoroughly purged and the colon well flushed with a soap-suds enema. The urinary bladder should also be emptied. Before beginning the examination the patient may be given a hypodermic injection of morphine and scopolamine. This tends to quiet the patient and to relieve to some extent the discomfort due to distention. The air or oxygen may be introduced through an ordinary lumbar-puncture needle after sterilization and cocainization of the skin. In cases of ascites the puncture is made at the lowest possible point in the median line. In those cases without ascites the puncture may be made in the median line either above or below the umbilicus or, as preferred by Goetze, through the left rectus muscle, 3 to 5 cm. below the umbilicus, or through the rectus just below the costal arch outside of hepatic dullness. The amount of gas introduced varies; in general one must be guided by the subjective symptoms of the patient. From 2 to 3 liters in the absence of ascites is usually sufficient. Rautenberg has used as much as 6 liters in cases of ascites after withdrawing the fluid. If ordinary air is used it may be introduced through a rubber tube by means of a Politzer bulb. If oxygen is preferred an ordinary oxygen tank may be employed with a manometer for control. The air or gas should be introduced very slowly. After sufficient gas has been introduced

the needle is withdrawn and the patient screened in various angles and positions. This will indicate the best position for radiograms. After the examination is completed the gas may be left to be absorbed or it may be expressed through the puncture needle wound by gentle pressure on the abdominal wall, or a slightly larger needle may be re-inserted through the original wound and the air allowed to escape through it.

Dangers and Complications.—(1) Puncture of the hollow viscera, (2) rupture of abscesses with liberation of infected materials into the peritoneal cavity; (3) fatal embolism by entering a blood vessel with the puncturing needle; (4) respiratory and cardiac disturbances; (5) severe pain in the shoulders due to gas distention; and (6) syncope.

It will be seen by a review of the literature that the method of diagnosis by means of pneumoperitoneum has many possibilities. For instance, Goetze's publications would lead one to believe that practically all organs of the abdomen and their diseases can be demonstrated by pneumoperitoneal roentgen examination. His opinion is doubtless colored by his enthusiasm, for he goes so far as to say that examination of the gastro-intestinal tract without air filling of the peritoneal cavity is not particularly promising. However, those who have had a vast experience with disease of the gastro-intestinal canal well know that lesions of the intestinal tract are best shown by the opaque method. Both Rautenberg and Goetze state that, while they have been able to see the gall-bladder, pericholecystic adhesions, etc., in many instances, they have not been able to demonstrate gall-stones consistently by this method. This is what might have been expected since the visualization of gall-stones depends on the percentage of calcium in the stones and on the density of the enveloping bile. It is disappointing, however, from a clinical standpoint, for any new method by which gall-stones might be discovered in a large percentage of cases would have marked a real advance in diagnosis.

Although the kidneys may be clearly shown and many

of their diseases are demonstrable by means of pneumoperitoneum, it is questionable whether it can be compared for accuracy with the data obtained without air inflation by means of radiography, cystoscopy, differential renal functional test and ureteropyelography.

The method of pneumoperitoneal roentgen diagnosis unquestionably has much merit, but because of its newness and the likelihood of its being used by the inexperienced it may come into considerable disrepute before its real limitations are learned. As in other x-ray work the difficulty will be in the interpretation of the picture and correlation of all roentgen findings. For this reason the roentgenologist should be chary of reading something into the plate that he does not clearly see.

If the patients for examination are carefully chosen pneumoperitoneum should prove a valuable aid to diagnosis, but it should be resorted to only after all other methods of examination have failed.

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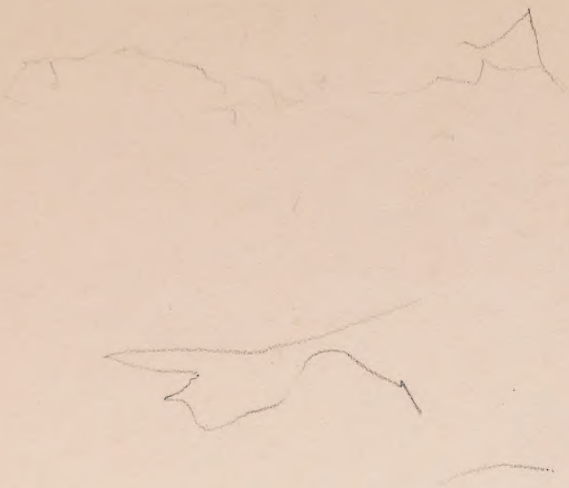
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